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GEOLOGICAL SURVEY OF OHIO

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GEOLOGICAL SURVEY OF OHIO

J. A. BOWNOCKER, State Geologist

FOURTH SERIES, BULLETIN 20

GEOLOGY OF SOUTHERN OHIO

INCLUDING JACKSON AND LAWRENCE COUNTIES
AND PARTS OF PIKE, SCIOTO, AND GALLIA

By WILBER STOUT

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1916

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HON. FRANK B. WILLIS, *Governor of Ohio:*

MY DEAR SIR:—I transmit herewith the copy for Bulletin 20, entitled the Geology of Southern Ohio, by Mr. Wilber Stout. The area discussed includes Jackson and Lawrence counties and parts of Scioto, Jackson and Gallia. The territory has large and varied resources whose development will add much to the wealth of our State. Mr. Stout's investigation has been unusually thorough and he has made the economic phase of the subject his principal theme. I believe that this Bulletin will be extensively consulted and that it will aid in the development of the area.

Respectfully submitted,
J. A. BOWNOCKER,
State Geologist.

Columbus, Ohio,
July 1, 1916.

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CHAPTER I

JACKSON COUNTY

Introduction

The salt springs near Jackson were utilized for the production of salt by the aborigines long before the advent of the white man, as is shown by the remains scattered throughout the region. During the early history of the state this was one of the important localities for this article, which was carried by the early settlers on pack horses for long distances. Next, the region located in the rich Ferriferous ore belt became known for its charcoal furnaces. This was followed by the opening of the valuable Sharon and Quakertown coal deposits which increased the activity and wealth of the region. At present, the county is of interest chiefly for its coals, clays, and iron ores.

Location and Area

Jackson County is situated in the southern part of the state in the second tier of counties from the Ohio River. It is bounded on the north by Vinton, on the east by Vinton and Gallia, on the south by Gallia, Lawrence, and Scioto, and on the west by Scioto, Pike, and Ross. Its area, according to the latest measurements and estimates of the Federal Government, is 410 square miles.

Topography

RELIEF

The entire county is decidedly hilly and rough excepting the valley floors of the old preglacial streams which traversed the region. It is a part of the Appalachian Plateau which has been highly dissected by both the old and present streams. The former streams had reached the advanced stage of comparatively broad valleys, with the adjacent hills low and well rounded, when the deflection from glacier agencies modified and changed their courses thus producing the present streams, some of which have cut new, gorge-like valleys, adding considerably to the already broken character of the region. From Jackson northward the deep entrenched valley of Salt Creek with its bold escarpments, very picturesque indeed, is an example of the work of the present streams in modifying the topography. The rugged surface relief of the western part of Jackson County is due partially to the erosive action of the streams on the soft, massive, Sharon conglomerate, often more than 100 feet in thickness, which outcrops in this section. This region is marked by the steep slopes of the main ridges whose projecting spurs often terminate in high cliffs, and by the restricted valleys of the main streams whose laterals often end in rocky gorges. Higher up in the coal measures, other massive sandstones are found which also have their influence. The highest points in the county have an elevation of about 1,050 feet above sea, while the elevation of the main valleys is between 600 and 700 feet.

On account of the character of the surface, and of the shale or sandstone soils, the county ranks low in agricultural products. It is better adapted to stock and fruit raising. The outcropping minerals are more easily obtainable in a hilly country, so that this has been an aid in the mining of the minerals. The main county roads and railroads by following the old water courses have low grades, but often circuitous routes.

DRAINAGE

Present System

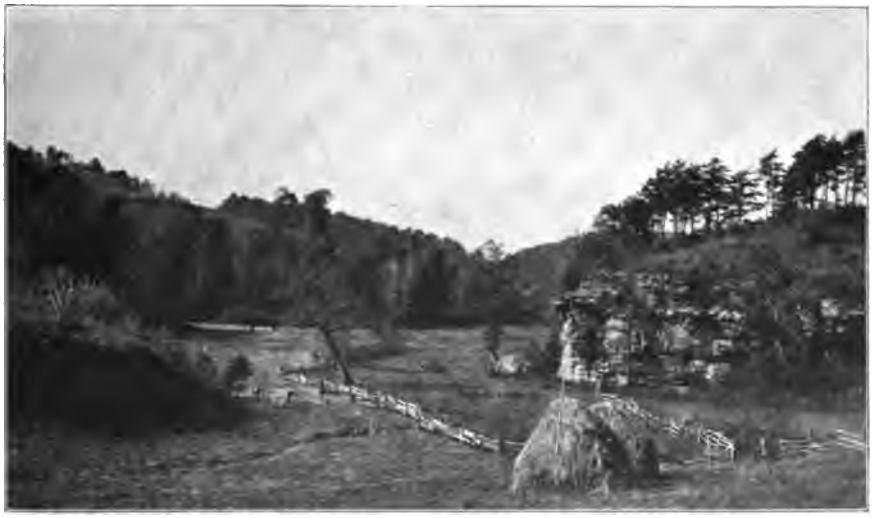
Jackson County is drained by a number of small streams whose waters, flowing from various directions, finally reach the Ohio River. Symmes Creek, flowing south to the Ohio, drains most of Madison and Jefferson and parts of Franklin and Bloomfield townships. Raccoon with its tributary, Little Raccoon, flowing southeastward to the Ohio, drains parts of Lick and Madison, most of Bloomfield, all of Milton, and the eastern parts of Coal and Washington townships. Symmes and Raccoon thus drain the eastern part of the county. Hales Creek, a tributary of Pine Creek, flows southward, and drains a small territory in southern Jefferson Township. Little Scioto River, which flows south and empties into the Ohio near Sciotoville, drains Hamilton, most of Scioto, the western part of Jefferson, and the southern part of Liberty. This stream drains the southwestern part of the county. Beaver Creek, flowing west to the Scioto River, just touches the western part of Scioto Township. Little Salt Creek, with Middle Fork, Salt Creek and its tributary Pigeon Creek, unite to form Salt Creek proper, which flows northwestward to the Scioto and drains a part of Scioto, most of Franklin, Lick, Liberty, Coal, and Washington, and all of Jackson townships. This stream drains the central and northwestern part of the county.

These streams are all small and during the summer the volume is insufficient for any large water supply. This handicaps the region for many manufacturing industries. Small springs, which furnish a sufficient supply for stock raising, are quite common, especially in the eastern part of the county in the limestone belt, and in the western part where the Sharon conglomerate is present. As a whole the county is not well watered.

Old Drainage System

The preglacial drainage of Jackson County was much different

A.—Jefferson Furnace, near Oak Hill, Jackson County. The only active charcoal furnace in Ohio in 1916. It was built in 1854 and has been in nearly continuous operation since that date.



B.—Topography along the outcrop of the Sharon conglomerate, Liberty Township, Jackson County. Narrow valleys with many bold cliffs are found.

from the present drainage system. Several quite large streams, the valley floors of which are now swampy, and contain only small sluggish streams, existed in the region, and are readily traced across the county. The broad California Valley, described in the report on Scioto County continues northward from Stockdale into Scioto Township, Jackson County, thence swings westward into Pike County near Beaver, and continues to the Scioto Valley near Waverly. Valleys of eastern tributaries to this main stream are found in the southwestern part of Jackson County. For a complete description of the drainage modifications in Jackson County the reader is referred to the work of Tight and also that of Leverett.[1]

In Jackson County the main stream traced and described by Tight is the Marietta River, which flowed westward from Centerville, Gallia County, and entered Jackson County in Section 24, Madison Township. From here the stream continued west to Symmes Creek, thence northwest with this stream to Section 21, thence past McKittrick, Clay, Banner, and Camba to Keystone, where it was joined by the Albany River from the north. From Keystone the stream flowed northward to Jackson, thence west and southwest through the southeastern part of Liberty into Scioto Township where the valley joins that of the California near Howells Crossing. The Albany River, which entered Jackson County just north of Wellston, flowed south past Berlin, Fairview School, and Ridgeland to Rocky Hill, where it turned and flowed westward to the Marietta River at Keystone.

The Marietta Valley in Jackson County is described by Tight as follows:

Cackley Swamps Valley.[2]—From Centerville the old valley continued northwestward up the valley of Grassy Fork to the open flat lands in the vicinity of the Cackley Swamps, south of Madison Furnace. The valley walls in this region are more completely graded than in the upper sections and at very much lower angles, and the hills immediately bordering the valley rise about 150 to 200 feet above its floor. The amount of silting in this region has been very great, and there are numerous minor modifications in the streams on both the Grassy Fork and some of its smaller tributaries, but these could be shown only on a very detailed map.

Camba, Keystone and Jackson Valleys.[3]—From the region of the Cackley Swamps the old valley extends along the line of the Portsmouth division of the Baltimore & Ohio Southwestern Railroad, past Camba Station, and on to the headwaters of the Salt Creek Valley at Keystone. The deposits in the valley at Camba are very deep, and it is back of these that the Cackley Swamps are found, which now are the headwaters of Grassy Fork of Symmes Creek. A well, sunk close to the railroad in the cut, penetrated 95 feet of blue clays and sands, and struck rock at that depth.

---

[1] G. W. Tight, Drainage Modifications in Southeastern Ohio and Adjacent Parts of West Virginia and Kentucky, Professional Paper No. 13, U. S. Geol. Surv. Frank Leverett, Glacial Formations and Drainage Features of the Erie and Ohio Basins, Monograph V. 41, U. S. Geol. Surv.

[2] Drainage Modifications in Southeastern Ohio and Adjacent Parts of West Virginia and Kentucky. Professional Paper No. 13. United States Geological Survey, p. 66.

[3] Ibid, pages 66-67.

This would indicate the valley floor to be about 650 feet above tide. The surface of the deposits at Camba is about 125 feet above the present surface of the valley at Keystone, the railroad having a grade in this section of about 100 feet to the mile. The valley here is about three-quarters of a mile wide, and its floor is very flat all the way from Keystone to Jackson. Indeed, it is so flat that it was, in the early days, almost entirely swamp area, many thousands of acres in extent, but most of the swamp has been reclaimed by cutting the timber and laying drain tiles. At Keystone are located the wells for the waterworks system for the city of Jackson. These wells penetrate from 12 to 20 feet of fine silts and then enter an extensive gravel stratum, which, as far as learned, was not entirely penetrated, so that the exact elevation of the rock floor was not determined. At this point also the old valley receives, on its eastern side, a large tributary of about its own size, entering from the direction of Rocky Hill.

Beyond Keystone the valley is drained by the South Fork of Salt Creek, which enters it about two miles past Jackson. At this point the creek turns abruptly to the north and cuts through a very narrow valley extending across the high tableland bordering the old valley, while the old valley continues to the west along one of the smaller tributaries of Salt Creek reversed, and enters the California Valley in the vicinity of Glade. The features below Keystone, and also of the tributary which enters this old valley at Keystone, are shown on the map.

The lower part of the Albany River Valley found in Jackson County is described as follows:

Wellston Valley.[1]—From Hamden the old valley passes around a high portion of the tableland which separates it from the present valley of the Little Raccoon; it then bends southward, and is occupied by the city of Wellston. The floor of the valley is here much cut up by the drainage lines tributary to the Little Raccoon, but it is evident that the sections of these streams between the valley and the Little Raccoon are all reversed at the present time. The headwaters of Middle Fork of Salt Creek have also eaten into the old divide, and caused the watershed to migrate towards the old valley to such an extent that the portion of the old divide is represented by a very narrow gorge, through which the drainage passes down Salt Creek.

Berlin Valley.[2]—From Wellston the valley runs almost due south to the vicinity of Berlin, where the floor of the valley is a water parting for another tributary of the Little Raccoon, Dickson Fork. At Berlin the valley is fully three-fourths of a mile wide, measured on the surface of the silt fillings, which are rather thick, although their exact depth was not determined. Much of this area is now represented by swamp lands which have been reclaimed by draining.

From the Berlin Flats the valley continues southward and is drained by Dickson Fork of the Little Raccoon. The old gradation plains along this section of the valley are well preserved, and where Dickson Fork leaves the valley, they stand at an elevation of about 50 feet above the stream. There are also well marked remnants of the old gradation plain on Dickson Fork, and these rise rapidly passing down the creek, showing that the old drainage was exactly the reverse of the present. From this point the valley passes somewhat to the southwest, beginning a great curve which it makes to join the valley already described at Keystone. At Rocky Hill, which is the summit of the Cincinnati, Hamilton & Dayton Railway, the old valley floor now stands at an elevation of about 700 feet above tide."

SURFACE ROCKS

Stratigraphy

The surface rocks, entirely of sedimentary origin, represent a maximum interval of about 900 feet. They consist of thick beds of conglomerates, sandstones, and shales, with thin strata of limestones, iron ores, coals, and clays. The preglacial and recent stream deposits, confined to the valley floors, belong to the Quaternary system, while the great mass of rock belongs to the Carboniferous system which is here subdivided into the Cuyahoga, Logan, Maxville, Pottsville, Allegheny and Conemaugh formations. In Jackson County the general section of the Maxville, Pottsville, and Allegheny formations, as represented in Ohio, is quite complete, for good exposures of practically all the members are found. The region has long been known for the representative beds of Sharon and Quakertown coals. The rocks of the Quaternary System are first described, then those of the Carboniferous, beginning with the oldest. The following general section shows the relation of the beds.

---

[1] Professional Paper No. 13, U. S. G. S., p. 71. [2] Ibid, p. 72.

General Relation of the Beds in Jackson County

System.	Series.	Formation.	Member.
Quaternary.	Recent.		Recent alluvium and gravel deposits.
	Pleistocene.		Glacial and old river deposits.
Pennsylvanian		Conemaugh.	Mahoning coal. Mahoning sandstone.
		Allegheny.	Upper Freeport, Waterloo, or No. 7 coal. Lower Freeport, Hatcher, or No. 6a coal. Middle Kittanning, Sheridan, Hocking, or No. 6 coal. Middle Kittanning clay. Red Kidney ore. Lost Seam coal. Oak Hill clay. Lower Kittanning, Newcastle, or No. 5 coal. Lower Kittanning clay and shale. Ferriferous, Limestone, or Baird ore. Vanport, Ferriferous, Hanging Rock, or Gray limestone. Clarion, Limestone, or No. 4a coal. Clarion clay. Canary ore. Clarion or Hecla sandstone. Brookville or No. 4 coal.
		Pottsville.	Homewood sandstone. Kidney ore. Tionesta, or No. 3b coal.

General Relation of the Beds in Jackson County—Concluded.

System.	Series.	Formation.	Member.
Pennsylvanian—Concluded.		Pottsville—Concluded.	Upper Mercer, Franklin, or Big Red Block ore. Upper Mercer limestone. Sand Block ore. Upper Mercer, Webster Block, or No. 3a coal. Lower Mercer, or Little Red Block ore. Lower Mercer limestone. Boggs ore. Lower Mercer, or No. 3 coal. Vandusen coal. Jackson Sand Block ore. Bear Run coal. Kidney ore. Quakertown, Wellston, Jackson Hill, or No. 2 coal. Black Band ore. Guinea Fowl ore. Anthony coal. Sciotoville clay. Sharon shales. Sharon, Jackson Shaft, or No. 1 coal. Sharon conglomerate. Harrison ore.
Mississippian.		Maxville.	Maxville limestone.
		Logan.	Vinton sandstone. Allensville sandstone and conglomerate. Byer sandstone.
		Cuyahoga.	Portsmouth shales.

The general dip of the rocks in the southern part of Jackson County, using the Ferriferous limestone as a basis, is 30 feet to the mile east and 33 feet southeast. In the central part of the county the dip is variable, but, measured by the Sharon coal for a distance of 10 miles, the fall to the east is 34 feet to the mile and southeast 48 feet.

In the northern part the dip to the east, measured by the Quakertown and Sharon coals, is respectively 27.2 and 27 feet to the mile, while the dip to the south, using the Lower Mercer limestone as the base, is 10 feet to the mile. The average dip for the strata is about 30 feet to the mile east, and 10 feet to the mile south. In many places the dip of the Sharon coal is abnormal for variations of from 15 to 20 feet in 100 yards are common. The strata above this are more regular, but local dips of from 5 to 10 feet are common to all.

QUATERNARY SYSTEM

RECENT DEPOSITS

The deposits of the present streams consist of rubble, gravel, sand, and silt, the amount of each depending primarily on the degree of fall of the stream, on the slope of the adjacent walls, and on the character of the rock. In Jackson County, the streams are small, and, excepting those in the old preglacial valleys, have narrow flood plains with only thin deposits containing considerable coarse material. In the western part of the county where the Sharon conglomerate is the wall or bed rock of the streams, the deposits consist largely of quartz sand, and gravel, while in the eastern part, where shales and sandstones predominate, the deposits are made up of clays and sands with some broken stone. The sand and gravel deposits have a local value but the clay beds are too thin to be utilized. The amount of vegetable matter carried by the laterals to the flood plains of the main streams is quite large, so that the land is very good for agricultural purposes; in fact, it is the most productive in the county.

PLEISTOCENE DEPOSITS

These deposits are found in the valleys of the old preglacial streams and consist principally of clays and sands, with some gravel and coarser material, such as bowlders from unknown sources and chert from the Ferriferous limestone. In some localities these deposits are very thick, and as given by Tight,[1] the deposits in the valley at Camba are very deep. A well, sunk close to the railroad in the cut, penetrated 95 feet of blue clays and sands and struck the rock at that depth. Other well records in these valleys show the deposits to be from 30 to 50 feet in thickness. The interbedded gravels, sands, and silts, found in the lower part of the deposits, represent the materials laid down by the streams during their normal cycles previous to the advance of the glacier. On the water divides and upper terraces, where the deposits have been least disturbed, are found thick beds of very fine-grained clays with exceptionally thin stratification planes, which appear to have been deposited during glacial time when lake-like conditions prevailed in these old valleys. As these valleys are free from glacial drift sands and gravels, they were not the direct water-ways for the floods of the melting ice sheet, yet the damming of the lower courses of the system produced a reversal of the drainage, and also caused a flood period during which the waters in these valleys were quiet, hence favoring the deposition of this type of sediments.

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[1] Professional Paper No. 13, United States Geological Survey, Drainage Modifications in Southeastern Ohio and Adjacent Parts of West Virginia and Kentucky, by W. G. Tight, page 66.

Economic Value

The clays in these old valleys are excellent material for red brick and drain tile. The beds are generally quite thick and the clays easily mined, as only a few inches of soil need be removed. The material requires no extensive grinding, but at most only crushing in rolls and thorough mixing with water in a pug mill to produce good working muds which flow through the dies, easily forming ware with but little defects. The ware dries readily and burns to a good red body at a low temperature. At present these deposits are not utilized in Jackson County.

MISSISSIPPIAN SYSTEM

Rocks belonging to this system are found in the western part of the county. In the southwestern part the width of the belt is about 4 miles, and the maximum thickness of the exposed rocks seldom exceeds 100 feet; but in the northern part the width is about 11 miles, and the maximum thickness of the beds is close to 300 feet.

In the Dever Valley an isolated pocket of Maxville limestone goes under cover in Section 14, Hamilton Township, and in the valley to the north of this the sandstones are last seen in the northern part of Section 14. The Mississippian rocks disappear on Bucklick Creek in Section 16, on Sugarcamp Creek in Section 33, Scioto Township, and just west of Petersburg in the central part of this township.

In the old Marietta Valley west of Jackson, Mississippian rocks are found near where Little Salt Creek leaves this old waterway. From here north to Canters Caves, Little Salt Creek marks the most eastern exposures. On Pigeon Creek they go under cover near Glen Nell, Section 20, Washington Township, and along the main line of the Baltimore & Ohio Southwestern Railroad they disappear in Section 10.

Between the close of the Mississippian period and the time represented by the Pennsylvanian rocks present in this region is a time interval of considerable length, as denoted by the extensive disconformity between the series. This break at the close of the Mississippian represents a period when at least a part of the region was a land mass and when the work of surface erosion, stream dissection, and shore action was active. In some places the line of disconformity is marked by conglomerate or brecciated masses of stone, shale, and clay, several feet in thickness; but as a general thing this is absent and the Pennsylvanian rocks rest directly but not conformably on the Mississippian. The invading sea worked over or destroyed the primary soil. The stream dissection of this land is shown by the sudden drops in elevation that mark the original valleys which may have remained practically unchanged or which may have been considerably modified by the sea during later submergence, since part of this Mississippian floor was subjected to the action of the powerful currents that laid down the Sharon conglomerate.

Some parts of this land mass of Mississippian rocks remained above water long after the beginning of the deposition of the Pennsylvanian strata. At the head of the Dever Valley an isolated mass of Maxville limestone stands out in Pennsylvanian deposits like an island in the sea. This remnant of Maxville limestone existed as a land mass until after the deposition of the Quakertown coal, or it was buried just before the Bear Run coal was laid down. It was land during the time required to deposit the thick Sharon conglomerate, and the mass of shales and sandstones with the intervening Sharon coal, Sciotoville clay, and Quakertown coal, or in all, strata representing a maximum thickness in Jackson County of over 200 feet. To this time interval must be added also that representing the erosion stage of the Mississippian prior to the deposition of the Sharon conglomerate. Other irregularities were also noticed but none as pronounced as that in the Dever Valley.

Of the Mississippian series only the Cuyahoga, Logan, and Maxville formations are found above drainage in Jackson County. Drill records show the entire series to be about 500 feet in thickness.

CUYAHOGA FORMATION

PORTSMOUTH MEMBER

Rocks belonging to the Portsmouth member of the Cuyahoga formation are found only in the northwestern part of Jackson County. The beds are exposed along the valleys of Middle Fork, Salt Creek, and Pigeon Creek. The interval is made up of siliceous shales and shaly sandstones. Some of the shale beds are fitted for the manufacture of clay products, but the sandstones have no value worthy of consideration.

LOGAN FORMATION

The upper division of the rocks in the Mississippian system is the Logan formation, which has been subdivided by Hyde into three members, Byer, Allensville, and Vinton.[1] These rocks extend well into Jackson County before they disappear from view. They are above drainage along the valleys of all the larger streams in Jackson Township, while in Washington Township they go below cover near Glen Nell Hollow on Pigeon Creek and east of Richland Furnace on its small tributary. Patches of Logan rocks are found below the massive Sharon conglomerate along the water courses in the northwestern part of Liberty Township, and they appear again in the southwestern part along the headwaters of the Little Scioto River. The formation is above cover in most of the western half of Scioto Township, while in Hamilton Township it disappears below drainage along the waters of Holland Fork near the village of Mabee and in Section 26. The full thickness of the Logan formation is exposed, however, only in Jackson Township.

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[1] J. E. Hyde, Stratigraphy of the Waverly Formations of central and southern Ohio. Journal of Geology, Vol. 23, pp. 771-779, 1915.

BYER MEMBER

The Byer member of the Logan formation is well exposed near the village of Byer in Washington Township and along Pigeon Creek west of this in Jackson Township. The deposit is found also in the western parts of Jackson and Scioto townships. It is made up of shaly sandstones with layers of siliceous shales intervening. The Byer member has no special value in Jackson County.

ALLENSVILLE MEMBER

The Allensville member which extends across the western part of Jackson County appears in Washington, Jackson, Liberty, Scioto, and Hamilton townships. It is composed of argillaceous sandstones, fine-grained conglomerates, and siliceous shales. The Allensville and Vinton members are usually well developed in the northern parts of Washington and Jackson townships. The following section obtained north of the Baltimore & Ohio Southwestern Railroad near Richland Furnace shows the general character of the member:

		Ft.	In.
Pottsville formation.			
Shale and covered		10	--
Ore, *Lower Mercer*		--	4
Shale and covered		85	--
Sandstone, massive, coarse-grained, cross-bedded		49	--
Covered		14	--
Logan formation.			
Sandstone, with parts covered	*Vinton*	38	--
Sandstone, ferruginous, fine-grained		20	--
Sandstone, coarse-grained	*Allensville*	2	--
Conglomerate, fine-grained		--	8
Sandstone		1	4
Conglomerate, fine-grained		--	11
Sandstone		2	3
Conglomerate, fine-grained		2	1
Sandstone		3	--

The following composite section which shows the relation of the Allensville strata to that of the Pottsville was taken on land of W. M. Muncy in Section 16, Washington Township:

	Ft.	In.
Pottsville formation.		
Shale and covered	18	--
Sandstone, cross-bedded, coarse-grained	25	--
Disconformity	--	--
Shale, sandy	6	--

		Ft.	In.
Pottsville formation.			
Ore, fossiliferous, *Sharon*		--	6
Shaly sandstones and sandy shales		14	6
Coal, *Sharon*, part bony		2	--
Clay, siliceous		2	--
Logan formation.			
Shale, siliceous		6	--
Covered		12	--
Sandstone	*Allensville*	5	--
Conglomerate, fine-grained		1	--
Sandstone		--	6
Conglomerate, fine-grained		--	5
Sandstone		--	4
Conglomerate, fine-grained		--	7
Sandstone		4	--
Covered		--	--

The rocks of the Allensville member are important stratigraphically, for the conglomerate layers are quite distinct from the associated beds, and the sandstone layers contain marine fossils which aid materially in tracing the deposits of the Logan formation. The worth of the beds otherwise is small.

VINTON MEMBER

The Logan age closed with the deposition of the Vinton member. It is also made up of sandstones and shales which, owing to the presence of iron pigments, have a yellowish color. The member is above drainage in parts of Washington, Jackson, Liberty, Scioto, and Hamilton townships. In northern Washington and Jackson townships the deposit consists principally of fine-grained sandstones, but in its southern extension it becomes more shaly in character. The section of the rocks, made near Richland Furnace and given under the Allensville member, shows the character and thickness of the deposit in northern Jackson County. Owing to the extensive erosion at the close of the Mississippian time the deposit in many localities is wanting or very thin. In Scioto and Hamilton townships it is shaly and usually thin. The Vinton member in most of the area in Jackson County varies from 30 to 60 feet in thickness. These measurements are about the same as those found for the deposit in its extension across Scioto County to the Ohio River near Sciotoville. The deposit contains but little material of value in Jackson County.

MAXVILLE LIMESTONE

The Maxville limestone is correlated with the Chester group of the West and with the Greenbriar in the Appalachian region.[1] It is overlain by an ore bed which is very intimately associated with it, and which was called the Maxville ore by Orton. It is believed to be basal Pottsville and the name Harrison ore is here adopted for it. It is better shown in Scioto County and is described in that chapter.

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[1] Geol. Survey of Ohio, Bull. 13, pp. 104–111.

The Maxville limestone is found only in Section 24, Hamilton Township, and the lower part of a record, made on the lands of Amos Canter and Joseph Woods, is as follows:

		Ft.	In.
Shale, dark, tough		3	--
Coal, *Bear Run*, reported thickness		1	1
Shale and covered		14	6
Sandstone, shaly		3	--
Sandstone, irregular, irony		1	--
Clay shale, light greenish		3	--
Limestone, irregular, with flint and iron ore, *Harrison* ore horizon		1	--
Limestone, gray	*Maxville*	1	6
Limestone, reported below		7	6

From the Canter quarry the deposit extends only a few hundred yards to the west, or down the valley, while to the east it soon passes under cover. Thus the total area is unknown but apparently quite small. This limestone was used to a small extent by the old charcoal furnaces for flux stone, and at present is quarried for local use in road building. No chemical analyses are available, but from appearances it has about the same quality as that from the Harper shaft in Scioto County.

PENNSYLVANIAN SYSTEM

The Pennsylvanian system of Jackson County is divided into three formations, the Pottsville, Allegheny, and Conemaugh. Pennsylvanian rocks are found in every township, and, in fact, in every section of the townships in Jackson County. In this area the entire thickness of the Pottsville and Allegheny formations is exposed, while only the lower part of the Conemaugh division is represented. The thickness of the Pottsville rocks in Jackson County is approximately 356 feet, while that of the Allegheny rocks is about 183 feet. There is only about 80 feet of the lower part of the Conemaugh formation present in this county.

Composite Section of the Pennsylvanian Strata in Jackson County

	Ft.	In.
Conemaugh formation.		
Shales	30	--
Coal, *Mason*	1	--
Shales and sandstones	31	--
Coal, *Mahoning*	1	--
Sandstone, *Mahoning*	20	--
Allegheny formation.		
Coal, *Upper Freeport, or No. 7*	3	--
Shales and sandstones	42	--
Coal, *Lower Freeport, or No. 6a*	1	--
Shales and sandstones	37	--
Coal, *Middle Kittanning, or No. 6*	1	10
Shales and sandstones	27	--

		Ft.	In.
Allegheny formation.			
Ore, *Red Kidney*		--	4
Shales and sandstones		3	8
Clay, *Oak Hill*		3	--
Ore, *Hamden*		--	--
Shale		2	--
Coal, *Lost Seam*		1	--
Shale		2	--
Coal	*Lower Kittanning, or No. 5*	2	4
Clay		--	3
Coal		--	6
Clay, *Lower Kittanning*		6	--
Shale and sandstone		6	6
Coal		--	6
Clay, shale, and sandstone		12	--
Ore, *Ferriferous*		--	6
Limestone, *Ferriferous, or Vanport*		6	--
Shale		1	--
Coal	*Clarion, or No. 4a*	1	3
Clay		--	7
Coal		1	4
Clay with pyrite		--	1
Coal		1	--
Clay		2	--
Sandstone, *Clarion, or Hecla*		16	--
Coal, *Brookville, or No. 4*		2	--
Pottsville formation.			
Ore	*Black Flint*	--	9
Flint		1	3
Shales and sandstones		21	--
Coal, *Tionesta, or No. 3b*		2	--
Shales and sandstones		27	6
Ore, *Upper Mercer*		--	6
Shales and sandstones		14	8
Ore, *Sand Block*		--	4
Shales and sandstones		8	6
Coal, *Upper Mercer, or No. 3a*		1	6
Shales and sandstones		18	--
Ore, *Lower Mercer*		--	4
Shales and sandstones		7	8
Limestone, *Lower Mercer*		1	--
Shales and sandstones		24	--
Ore, *Boggs*		--	6
Coal, *Lower Mercer, or No. 3*		2	--
Shales and sandstones		25	--
Coal, *Vandusen*		1	--
Shales and sandstones		8	--
Ore, *Jackson Sand Block*		3	--
Shales and sandstones		12	--
Coal, *Bear Run*		2	--
Shales and sandstones		5	--
Ore, kidney		--	6
Shales and sandstones		19	6
Coal, *Quakertown, or No. 2*		3	--

Pottsville formation.	Ft.	In.
Shales and sandstones	36	--
Ore, *Guinea Fowl*	--	6
Shale	3	--
Coal, *Anthony*	--	6
Clay, *Sciotoville*	5	--
Shale and sandstones	32	--
Ore, *Sharon*	--	6
Shale	5	6
Coal, *Sharon, or No. 1*	3	--
Conglomerate, *Sharon*	60	--
Ore, *Harrison*	--	10

POTTSVILLE FORMATION

Much of the present wealth of Jackson County is due to the valuable Sharon and Quakertown coal deposits which occur in this formation, and which have been mined for many years, but now are rapidly becoming exhausted. The Sharon coal is yet an important asset in the manufacture of iron in the district, and the reputation of the Quakertown coal is such that it commands the highest market prices. The Jackson Sand Block ore has also had an influence on the iron industry of the region. While of but little importance at present, the western part of the county is noted for the massive deposit of Sharon conglomerate, often over 100 feet in thickness, in which the streams have cut many deep gorges with abrupt walls, with projecting cliffs, and with occasional caverns that give to the region a rugged beauty scarcely exceeded in the state.

HARRISON ORE

The Harrison ore is found only in the southern part of Hamilton Township. The position of this ore is directly above the Maxville limestone when both are present, but the ore is found in a number of places where the limestone is absent. At some places this deposit is regular in structure and constant in thickness and composition, while at other places where it represents the line of disconformity between the Mississippian and Pennsylvanian series, it is very irregular in structure, and is composed of a mixture of ore, flint, sandstone, and clay.

In Section 24 the ore has been dug on the Amos Canter and adjoining properties, where the strata are as follows:

	Ft.	In.
Sandstone	3	--
Clay shale, light greenish	3	--
Limestone, with flint and ore, *Harrison*	1	--
Limestone, *Maxville*	9	--

In Section 27, on the property of D. E. Ruth, the ore was seen in the bed of the stream along the road that leads from the Dever Valley to Mabee. The section is as follows:

	Ft.	In.
Coal, *Bear Run*, reported thickness	2	--
Covered, barometer measurement	75	--

	Ft.	In.
Shale	10	--
Ore, very irregular, with sandstone and chert, *Harrison*	--	8
Shale, *Logan*	10	--

The ore here is 85 feet below the Bear Run coal, while on the Canter property, where the ore is in its natural position above the limestone, it is only 21 feet below the same bed. The difference in interval is 64 feet, which gives some idea of the disconformity or the extent of erosion that took place at the close of Mississippian time. Near the center of Section 14, close to the bridge that crosses the Little Scioto, on the land of Phillip Meldick, the strata exposed are as given below:

		Ft.	In.
Sandstone, coarse-grained, irony	*Sharon* conglomerate equivalent	1	10
Shale, blue		--	1
Sandstone, coarse-grained, irony		1	10
Ore, composed of small nodules, *Harrison*		--	10
Clay shale, light		2	--
Sandstone, with parts covered	*Logan*	15	--
Shale, soft, yellowish		1	6

About 200 yards west of this another section shows the following members:

		Ft.	In.
Sandstone		4	--
Shale, with *Guinea Fowl* ore in the interval		5	--
Coal blossom, *Anthony*		--	6
Clay, plastic, *Sciotoville*		4	--
Shales and covered		18	4
Ore, layer, small nodules of ore cemented by iron oxides, with light clay sandstone nodules and a few pebbles, *Harrison*		--	8
Sandstone, shaly	*Logan*	11	4
Sandstone, ferruginous		--	8
Sandstone, light blue		3	--

The quality of the Harrison ore is usually poor as it is more or less siliceous or flinty. Small amounts were mined in a few localities for the charcoal furnaces during their period of activity, but at present the ore is of no importance.

SHARON CONGLOMERATE

The basal member of the Pottsville formation, except the Harrison ore, is the Sharon conglomerate which rests unconformably on the Maxville or on the Logan when the former is wanting. This member is found in Hamilton, Scioto, Liberty, Lick, Coal, Jackson, and Washington townships. The deposit is very thick in parts of Liberty and Jackson townships, while it has good volume also in local areas in Hamilton, Scioto, and Lick townships. A general discussion of the Sharon conglomerate and its relation to other members is embodied in the next few pages.

Hamilton Township.—In the western part of Hamilton Township, south of Holland Fork, only occasional thin pockets of Sharon rock are found, but north of this stream the bed is very thick. West of the home of Martin Comer, in Section 16, from 30 to 40 feet of Sharon conglomerate are exposed above the bed of Bucklick Creek, while east of his home the rocks are clays and shales of later age, hence the top of the deposit varies in elevation from 30 to 40 feet in less than 200 yards. On Little Bucklick Creek massive cliffs of Sharon are exposed.

Scioto Township.—On Sugarcamp Creek the Sharon bed passes from view in Section 27, Scioto Township, while farther down stream the deposit often reaches a thickness of from 40 to 60 feet. Here the irregularity of both the upper and lower surfaces is found. In Section 9, on the lands of Fred Flaker and William B. Pratt, a section taken is as follows:

	Ft.	In.
Clay, *Sciotoville*, reported thickness	2	--
Sandstone	2	--
Shales and covered	35	--
Coal blossom, *Sharon*, reported here, seen across hollow, 3 feet thick	--	--
Covered	18	--
Conglomerate, *Sharon*	24	--

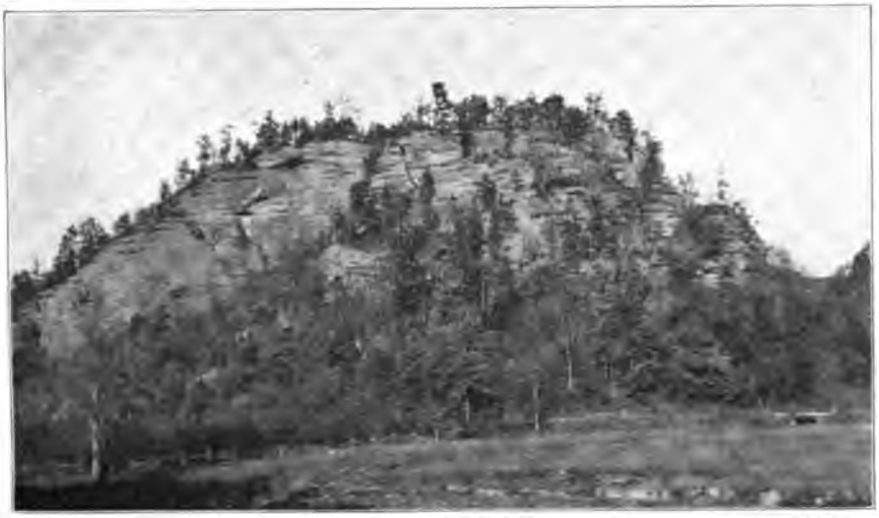
In the hill to the east of this over 40 feet of conglomerate are exposed. It is also quite thick in the vicinity of Cove School and goes under cover near the Jackson-Petersburg pike in Section 11. A few feet of conglomerate were seen in the creek bed at the cross-roads in the northeastern part of Section 3, but farther down stream the deposit is quite thick. In the northeastern part of Scioto Township the Sharon is found in a continuous bed, but varies considerably in thickness. A section on the Robert Lamb property, in Section 6, is representative of the members, and is as follows:

	Ft.	In.
Clay, *Sciotoville*	6	--
Covered, barometer measurement	32	--
Sandstone, massive	5	--
Coal, *Sharon*	2	4
Covered	10	8
Sandstone } *Sharon*	10	--
Conglomerate }	16	--
Covered	10	--
Sandstone, *Logan*.		

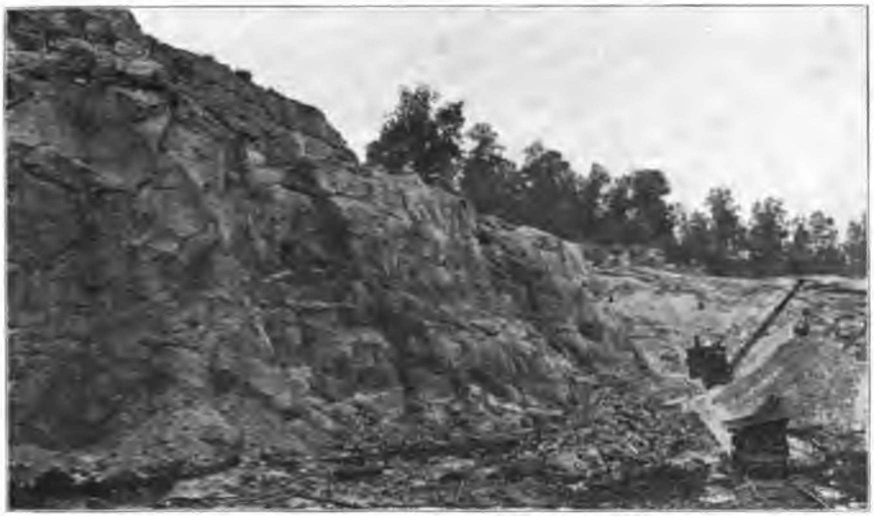
North of Scioto Township the Sharon swings eastward, going below drainage near the town of Jackson, where this roll or drop of the upper surface is very pronounced.

Lick Township.—The sudden dip of the Sharon coal and conglomerate was observed at the foot of the shaft of the Jackson Iron & Steel Company, at the mine on the next hill north, and at the knob just north of Booth's mine. The dip in each of these runs from 15 to 25 feet.

On the S. B. McKittrick property, just north of Jackson, the Sharon



A.—Vance Rock, a massive cliff of Sharon conglomerate about 200 feet high. In Liberty and Washington townships, Jackson County, the outcrop of this member is marked by many such exposures.



B.—Mine of the Jackson Sand Mining Company north of Coalton. The exposure is Sharon conglomerate, but here it assumes a sandstone phase and contains but few pebbles.

coal has been opened, and the massive sandstone, the equivalent of the conglomerate, is well exposed along the stream. A section here is as follows:

	Ft.	In.
Ore, with pebbles, *Guinea Fowl*	--	4
Shales and covered	34	--
Coal, *Sharon*, reported thickness	1	8
Sandstone, massive, *Sharon*	50	--

George Palmer reports the coal to dip east rapidly. The continuation of the roll from the Booth mine would throw the coal, which is found at this point, under Jackson, where the large deposit was worked for many years. No records are available showing the thickness of the Sharon conglomerate in the basin under Jackson.

Liberty Township.—The Sharon conglomerate is found in every section in Liberty Township, and in most of the area it is massively developed, often exceeding 100 feet in thickness. In the western part of the township it is usually a very pebbly conglomerate, but in the eastern part it is often a sandstone with only occasional pockets of pebbles. The conglomerate goes under cover in Section 35, Liberty Township, near the old Hammertown mine, which is east of the main hollow where the level of the Sharon coal is below drainage. In a branch hollow northwest of the mine the bony blossom of the Sharon coal with about 20 feet of conglomerate below was found. Tracing these around the hill to the southeast both beds were found to hold about the same level to the point just west of the mine. At this point the coal makes a sudden dip of over 21 feet, and then it thickens and changes in quality, so that it was formerly worked for railroad shipment. The dip in crossing the narrow hollow is over 21 feet. Whether the coal here rests directly on the conglomerate could not be determined as the mines have all fallen in. Along the stream north of this the massive conglomerate is well exposed.

At the Armstrong mine, in Section 28, the following strata were seen:

	Ft.	In.
Shale, dark, tough	21	--
Coal, *Sharon*	2	6
Shale, dark, carbonaceous	3	--
Conglomerate, *Sharon*	40	--

In Section 25, on the land of John Scurlock, the heavy dip of the Sharon coal is also found and the conglomerate was seen in the hollow just a short distance below. On the property of Edward Smith, in Section 13, Liberty Township, a section near Salt Creek is as follows:

	Ft.	In.
Shale	12	--
Coal, *Sharon*	2	10
Covered	2	--
Conglomerate, *Sharon*	80	--

The Sharon conglomerate is wanting in some localities in Sections 30, 31 and 32, Liberty Township. In Section 29 the rocks exposed along the road north of the home of Lewis Albert were as follows:

	Ft.	In.
Sandstone, soft, coarse-grained, parts with fine pebbles	31	--
Clay shale, dark, carbonaceous	1	--
Sandstone, soft, lower part argillaceous	11	--
Covered	2	--
Shale	3	--
Covered	1	6
Coal, shaly, *Sharon*	2	6
Clay, light, plastic	4	--
Covered	8	--
Conglomerate, pebbly, *Sharon*	35	--

At the old mine, Decatur No. 2, Section 24, the following strata were exposed:

	Ft.	In.
Ore, with pebbles, *Guinea Fowl*	--	11
Covered	4	--
Sandstone, with occasional pockets of pebbles	23	--
Covered	9	--
Coal, *Sharon*, reported thickness	3	--
Covered	5	--
Sandstone with some pebbles, *Sharon*	30	--

Along the road west of the house of Martha Lake, in Section 23, the Sharon coal is wanting, and the coarse-grained sandstone above this horizon meets the underlying Sharon conglomerate. The section taken is as follows:

	Ft.	In.
Ore, siliceous, *Guinea Fowl*	--	9
Shale	5	6
Ore, kidney	--	2
Shale	--	6
Ore, kidney	--	1
Clay, *Sciotoville*, on outcrop shows flint with semi-flint below	5	6
Covered	6	--
Sandstone, massive, cross-bedded with a few pebbles	14	--
Disconformity, horizon of Sharon coal.		
Conglomerate, *Sharon*, massive	19	--

On the land of W. M. Overly, in the northeast corner of Section 22, the Sharon conglomerate is well developed, and its relation to the Sharon coal is shown in the following section:

	Ft.	In.
Coal, *Sharon*	3	--
Covered	6	--
Conglomerate, *Sharon*	50	--

A composite section at the James Bryan coal mine shows the following relations of conglomerate and coal above:

	Ft.	In.
Sandstone, with fine pebbles	8	--
Coal, *Sharon*	3	6
Clay and argillaceous sandstone	2	--
Conglomerate, *Sharon*	25	--

Along the road that leads from Dry Run to the hill south in Section 18 the following rocks were exposed:

	Ft.	In.
Sandstone, loosely cemented, cross-bedded, upper part coarse-grained	47	--
Covered	33	--
Shale	10	--
Coal blossom, *Sharon*	--	6
Clay, sandy	2	6
Conglomerate, *Sharon*	102	--
Covered	10	--
Sandstones and shales, with parts covered, *Logan*	65	--

In this locality the conglomerate is very thick, often exceeding that shown in the section above. In Section 13, in the western part of Liberty Township, on the land of Rush Hartley, the conglomerate is very thick, as shown by the following section:

	Ft.	In.
Shale, dark	--	8
Coal, *Sharon*	2	6
Covered	6	--
Conglomerate, *Sharon*	105	--
Shale, *Logan*	10	--

The bare isolated hill in Section 12, known as Big Rock, is composed of Sharon conglomerate, whose exposure exceeds 100 feet. The massive thickness of the conglomerate, and the relation of the coal above are shown in the section given below, which was made on land of Walter Coy, in Section 17, Liberty Township.

	Ft.	In.
Shale	5	--
Coal, *Sharon*	2	6
Clay	1	6
Conglomerate, *Sharon*	145	--

Near this, the gorge-like valley known as White's Gulch is an example of stream erosion in the conglomerate. In Section 16, just north of the gulch, a section taken on land of Samuel White shows the thickness of the conglomerate. The record follows:

	Ft.	In.
Shale	--	3
Coal, *Sharon*	2	2
Clay, dark	1	--
Covered	8	--
Conglomerate, *Sharon*	110	--

On land of G. A. Ewing, in Section 14, the conglomerate exposed measured as follows:

	Ft.	In.
Sandstone, coarse-grained, with some pebbles, and covered	60	--
Blossom of Sharon coal.		
Conglomerate, *Sharon*	105	--

In Section 13, on land of Louis Ray, the relation of the Quakertown coal, Sciotoville clay, and Sharon coal to the Sharon conglomerate is shown by the section taken at that place which is as follows:

	Ft.	In.
Coal, *Quakertown*, reported thickness	2	6
Covered	58	--
Sandstone	10	--
Clay, flint Clay, plastic } *Sciotoville*	1 1	2 10
Coal blossom, *Sharon*	1	--
Clay, dark, siliceous	2	--
Conglomerate, *Sharon*	91	--

On land of Isaiah Burnett, in Section 11, the same general relation between the coals and the underlying conglomerate is shown in the section given below:

	Ft.	In
Coal, *Quakertown*	3	1
Clay	1	--
Covered	45	--
Sandstone	20	--
Shales, carbonaceous, *Sharon* coal horizon	2	--
Conglomerate, *Sharon*	100	--

Along Rock Run the Sharon conglomerate is very thick and this condition is shown by the following record taken on land of John Crossin in Section 10:

	Ft.	In.
Coal, bony, *Sharon*	--	6
Clay, sandy, blue	--	8
Conglomerate, *Sharon*	105	--

On land of J. M. Vance, Section 8, the rocks exposed measured as follows:

	Ft.	In.
Sandstone, with both fine and coarse pebbles	7	--
Shale	2	6
Coal, good Coal, bony } *Sharon*	1 --	8 4
Clay, and covered	5	--
Conglomerate, *Sharon*	60	--

The Sharon conglomerate in the northern part of Section 3 has thinned, as shown by the following section, taken on land of A. B. Erwin:

	Ft.	In.
Coal, shaly, *Sharon*	3	--
Conglomerate, *Sharon*	11	--
Sandstones and shales, *Logan*	70	--

In the same section, south of the above locality, the conglomerate is much thicker. The measurement of the rocks exposed along the road near the home of J. M. Bower is given below:

	Ft	In.
Ore, with pebbles, *Sharon?*	--	6
Sandstone	5	--
Covered	2	--
Sandstone, with pebbles	2	--
Shale	1	--
Coal blossom and clay, *Sharon*	1	--
Conglomerate, *Sharon*	55	--
Sandstone, *Logan*	85	--

The relation of the upper coals to the Sharon conglomerate is well shown in the following section, taken on land of D. D. Edwards, in Section 2:

	Ft.	In.
Sandstone, shaly	3	--
Coal, *Quakertown*	3	6
Clay shale	1	6
Covered	42	--
Sandstone, ferruginous	2	--
Sandstone, with large pebbles, *Guinea Fowl* ore horizon	1	--
Clay, sandy, flinty } *Sciotoville*	1	6
Clay, light, soft	10	6
Sandstone, and covered	23	--
Shale, with thin ferruginous sandstone	5	--
Sandstone, shaly	5	--
Shale, blue	7	--
Coal, bony, *Sharon*	--	4
Clay, blue, plant marked	2	6
Covered	4	--
Conglomerate, *Sharon*	90	--

A record made on land of James Wilson, Section 1, northeast, Liberty Township, shows the relation of the Quakertown and Sharon coals to the conglomerate below. The section follows:

	Ft.	In.
Coal, *Quakertown*	3	1
Clay	1	--
Covered	16	--
Sandstone, this on point facing Salt Creek thickens to 60 feet	18	--
Covered	40	--
Coal blossom, *Sharon*	--	3
Covered	25	--
Conglomerate, *Sharon*	45	--

In Section 1, northwest, Liberty Township, the rocks exposed on land of Neal Austin are as follows:

	Ft.	In.
Sandstone	10	--
Coal, *Sharon*, reported thickness	3	7
Clay, and covered	5	--
Conglomerate, *Sharon*	40	--
Sandstone, *Logan*.		

Coal Township.—The Sharon conglomerate is also prominent in some localities in the western part of Coal Township. In the northwest corner of Section 6, on land of C. M. Haslett, there is a roll in the conglomerate with a dip of 32 feet in a short distance. In the low part of this trough there are 2 feet, 6 inches of black shale representing the Sharon coal. Near the mouth of the hollow the conglomerate measured 70 feet in thickness. A composite section, taken from the point west of the Jacob Sells home, Section 32, to the bed of the stream west shows the relation of the conglomerate to the overlying coals and Mercer limestone. The section taken is given below:

		Ft.	In.
Limestone, *Lower Mercer*, on summit of point, weathered, but in place		--	8
Shale, and covered, by aneroid measurement		130	--
Coal, *Quakertown*		2	8
Covered		70	--
Sandstone		2	--
Bone shale, black	*Sharon* coal	1	2
Coal, bony		--	5
Clay shale, dark		1	5
Bone coal		--	6
Clay, siliceous, upper part dark		5	6
Sandstone, *Sharon conglomerate* equivalent		5	--

Jackson Township.—The Sharon conglomerate is very thick in the southern part of Jackson Township, but thins northward, and in places is entirely wanting. In Section 36 on land of William McKinnin a roll of 25 feet was noted in the massive conglomerate. Black shales on the horizon of the Sharon coal lie in the trough or low part of the conglomerate, while on the hill above the Quakertown coal is mined for local use. The section taken at this point follows:

		Ft.	In.
Shale, blue.			
Coal	*Quakertown*	3	6
Coal, bony		--	5
Covered		62	--
Sandstone		6	--
Shale, gray		2	--
Shale, dark, carbonaceous, *Sharon* coal horizon		1	--
Shale, siliceous		1	--
Conglomerate, *Sharon*		80	--

On land of John Faulkner, in the same section, the following thickness of the conglomerate was exposed:

		Ft.	In.
Coal	*Quakertown*	2	7
Coal, bony		--	6
Sandstone, and covered		80	--
Coal blossom, *Sharon*		--	6
Clay, light, sandy		4	6
Conglomerate, *Sharon*		95	--

At Canters Caves the maximum thickness of the Sharon conglomerate is about 200 feet, and it is generally pebbly and highly cross-bedded. In Section 34, on land of Charles H. Cosby, the following section shows a decided thinning of the conglomerate:

	Ft.	In.
Conglomerate, *Sharon*	35	--
Sandstones, *Logan*	50	--

Just north of Canters Caves, on land of Lawrence Harris, the following measurements were made:

	Ft.	In.
Coal blossom, *Quakertown*	1	--
Sandstones, and covered	97	--
Conglomerate, *Sharon*, top sandy	168	--

In Section 23, on the land of J. M. Ray, the relation of the conglomerate to the rocks above is shown by the following section:

		Ft.	In.
Shale		--	5
Coal	*Sharon*	--	9
Clay shale, dark		--	3
Coal, somewhat bony		1	9
Clay, dark, siliceous		1	--
Covered		8	--
Conglomerate, *Sharon*		75	--

The thickness of the conglomerate exposed along the road that leads from Little Salt Creek to the knob east in Section 21 is shown in the record below:

	Ft.	In.
Sandstone, coarse-grained, with a few pockets of pebbles	14	--
Covered	3	--
Shale	6	--
Sandstone, coarse-grained, with pebbles, ferruginous	2	--
Shale	1	--
Coal blossom, *Sharon*	--	6
Clay, bluish	2	--
Conglomerate, *Sharon*	58	--
Sandstones and shales, *Logan*	125	--

The conglomerate is much thicker west of the above, but no measurements were taken. The deposit is very thick in Section 24, but in Section 13, just north, it is thin or wanting. A section taken on land of Clinton Harper, given below, shows its absence:

	Ft.	In.
Pottsville formation.		
Sandstone, soft	30	--
Shales, and covered	9	--
Shales, dark, carbonaceous, *Sharon* coal horizon	1	--
Clay shales, blue	9	--
Logan formation.		
Shales	13	--
Conglomerate, fine-grained	1	4
Shales	17	--

	Ft.	In.
Covered	16	--
Sandstones and shales	30	--
Conglomerate, fine-grained	1	5
Sandstone	5	--

The conglomerate is thin or wanting in sections 14, 15, and 16, but in Section 17 it becomes prominent again, as shown in the following section taken east of the Pleasant Valley School:

	Ft.	In.
Sandstone, coarse-grained, and with fine pebbles	30	--
Conglomerate, *Sharon*	60	--
Sandstones, *Logan*.		

In sections 1, 2, 3, 4, 9, 10, 11, and 12, the conglomerate is generally wanting, but when present it is thin or broken by intervening shales. In sections 5, 6, 7, and 8, the conglomerate is present in some localities, although it seldom has a thickness of over 30 feet.

Washington Township.—The Sharon conglomerate occurs in local areas in the western part of Washington Township. Where present it is usually very thick, apparently filling low depressions in the Logan shales below. At the mine of the Jackson Sand Mining Company, in Section 20, Edward Mathews reports the lower sandstone, which is the conglomerate equivalent, to be 50 feet in thickness. At the old Glen Nell mines the intervals from the Quakertown and Sharon coals to the conglomerate below are shown in the following section:

	Ft.	In.
Sandstone, and covered	80	--
Coal, and covered, *Quakertown*	2	--
Shales, and covered	74	--
Coal, *Sharon*, thickness reported	3	--
Covered	3	--
Conglomerate, and covered, *Sharon*	15	--

In Section 17, near where the pike leaves Pigeon Creek, a local deposit of the conglomerate is again exposed, and measurement shows it to be 108 feet in thickness. The upper part is a coarse-grained sandstone, highly interbedded, with fine-grained pebbly layers, while the lower part, although usually sandy, contains zones of both fine and coarse pebbles.

Liberty Township.—On Pigeon Creek, south of Eastburn, the valleys are unusually gorge-like, and White's Gulch is probably the roughest and wildest spot in southern Ohio. The valley is narrow, with high massive walls and projecting cliffs of dull gray conglomerate. In sharp contrast to the somber hues of the rocks are the plants growing in the crevices and along the ledges, anywhere that a bit of soil is collected to give them root-hold. Even the sheer vertical cliffs, where they are shielded from the sun, are often green with mosses or liverworts. Many species of rock-loving plants are represented here, each seeming to find its own most favorable environment with regard to moisture, light exposure and other conditions. At the base of the cliff are huge masses of broken rock, among which are various species of hardy trees, growing tall and straight in their efforts to spread their leaves to the rays of the sun. Under the protection of their dense shade numerous delicate ferns and creepers grow in association with other plants that thrive best in deep shady valleys. The abrupt, massive cliffs, and the profusion of plant life along the valley, watered by the meandering stream, unite to form a scene of wild beauty such as is seldom found in Ohio. Along the course of Little Salt Creek the Sharon conglomerate also forms many long lines of rugged cliffs. The small gorge-like valley known as Canters Caves is a cool and attractive place for summer outings. The upper course of Rock Run is walled in with massive cliffs of conglomerate often over 100 feet in height.

A feature of importance also, especially for stock raising, is the large number of fine living springs that are found near the base of the conglomerate. The flow is strong, even in the dry seasons, and the water pure and cold.

Character of the Sharon Conglomerate

In Jackson County the Sharon deposit, markedly cross-bedded, is very pebbly, except in the region near Jackson and Coalton, where it is a coarse-grained sandstone with only occasional pebbles. The mass is loosely cemented, except the thin ferruginous layers along the bedding planes, which stand out prominently where the weathering of the surface has been severe. The main cementing materials are compounds of iron, but other factors are forms of lime and silica. The pebbles and sand grains, composed of crystalline quartz or quartzite, and thus of igneous origin, constitute the great mass of the deposit. Feldspars, magnetite, basic silicates, and other granitic minerals are also present, but only in small amounts. Practically the deposit is made up of various sized particles of quartz or quartzite with a small amount of iron compounds for the bonding material. In general the pebbles have a milky color, numerous cracks, and a high polish. They are well rounded and the usual shape is that of a prolate spheroid. The size of the pebbles varies from that of a hen's egg down, but the usual range is from that of wheat grains to that of acorns. The proportion of sand to pebbles also varies greatly. In places the deposit, as a whole, exceeds 70 per cent pebbles, counting as pebbles that material above a 20 mesh size, while elsewhere it is a sandstone with a few scattered pebbles.

The material is of foreign origin, derived probably from the great igneous masses to the north and brought down by strong oceanic currents during the transgression of the sea at the beginning of Pennsylvanian time. I. C. White, Ashburner and others, have shown that this conglomerate in Ohio is the equivalent of the Garland, or Olean, in Pennsylvania, and of the Olean in New York.

Axis of the Deposit

There are a number of interesting features in regard to the Sharon conglomerate. In Scioto, Pike, and Jackson counties, in the area in which this member is above drainage, the conglomerate seems to have been deposited in a valley-like depression in the Mississippian strata, the direction of the main axis of which is nearly north and south. In this field the southern terminus exposed is in the northeastern part of Porter Township, Scioto County. From surface exposures and well records the width in Bloom and Harrison townships appears to be from 1 to 4 miles. No thick deposit at least was noted in Harrison Township west of the old California Valley, and in Bloom Township it is wanting near the head of Bear Run where the horizon goes under cover, and was not found in the shaft and drill tests put down on the Harper farm south of Bloom Furnace. In the southern part of Madison Township, Scioto County, and Hamilton Township, Jackson County, the main deposit is 5 or 6 miles in width. In Madison Township only a few thin sandy deposits were found west of the California Valley, while in Hamilton Township it is wanting in the eastern part of the Dever Valley. In the northern parts of these townships the width is somewhat greater. The eastern edge of the deposit is not known, as the conglomerate continues under cover, but the rate of thinning indicates that it does not extend far eastward. The sheet expands to 12 miles or more in Union and Marion townships, Pike County, and Scioto Township, Jackson County. The deposits in western Union Township, although in places reaching 50 to 60 feet in thickness, appear to be somewhat local in character, for the conglomerate is poorly represented south of Owl Creek or north of the Beaver Valley in Western Beaver Township. In Scioto Township the stratum is generally thin where it goes under cover on the headwaters of Sugarcamp Creek, near Petersburg, and near Cove School on Buckeye Creek. In Beaver and southern Jackson townships, Pike County, and in Liberty, Lick, and southern Coal townships, Jackson County, the conglomerate is massively developed and the width of the main sheet exposed is approximately 10 miles. In Beaver Township the conglomerate is found principally in the eastern tier of sections, although there is a small isolated area near Rock Springs School in the western part, which also extends into Seal Township. In southern Jackson Township, Pike County, the thick deposits are confined to the main ridge with its eastern spurs that separate the headwaters of Cars Run from those of Pigeon Creek. In Liberty Township the stratum, usually very thick and pebbly, extends across the entire area. In western Lick Township the conglomerate, although very thick, has assumed a sandstone phase, which indicates that the deposits were not laid down in the direct line of the main currents. No drill records were obtained showing how far the stratum extends under cover, but, from the nature of the deposits seen along Pigeon Creek north of Coalton, it extends apparently no great distance. The width of the sheet exposed in northern Jackson Township, Pike County, southern Jefferson Township, Ross County, and in Jackson, Coal, and Washington townships, Jackson County, is also about 12 miles. In northern Jackson and southern Jefferson townships the stratum, usually massive and containing thick layers of very coarse pebbles near the bottom, continues westward with few wants to the Scioto Valley. In Jackson Township, Jackson County, the conglomerate is generally very thick along Pigeon and Little Salt creeks, but it is either wanting or thin and generally sandy in the northeastern part south and east of Ray. In Washington Township in the vicinity of Byer the conglomerate is generally wanting, but south of this along Pigeon Creek in sections 17 and 18 it is present in thick local deposits which are very sandy. Apparently these deposits are close to the eastern edge of the field.

Some idea of the main trend of the current action may be obtained from the general thickness and character of the stratum. If the stratum continues from Porter Township, Scioto County, the trend is eastward, for the conglomerate is not represented, at least in any considerable thickness, along the Ohio River from Portsmouth to near Hanging Rock where the Mississippian rocks go below drainage. From northeastern Porter Township, the general direction of the main axis of the deposits is north to the Scioto County line in Section 1, Madison Township. It follows closely the general course of the Little Scioto River. From this point the deposits seem to divide, one extending westward through southern Marion and Union townships, Pike County, and the other through central Scioto Township, Jackson County, into central Liberty Township. The lower part of the stratum in Marion and Union townships is generally very pebbly, indicating strong current action. West of this the horizon passes above the summits of the ridges. In central and western Liberty Township the conglomerate is very thick and pebbly, but in Lick Township it becomes sandy, especially in the vicinity of Jackson, while in Beaver Township, Pike County, it thins and is wanting.

From central Liberty Township the main bed swings northward through Jackson Township, then westward through northern Jackson Township, Pike County, and southern Jefferson Township, Ross County, to the Scioto Valley. On the main ridges from Richmondale south to Hog Hollow the conglomerate is very thick, and the lower part is made up of very coarse pebbles, some larger than a hen's egg. The size of the pebbles here would indicate that this was the main line of current action. Southern Harrison and Richland townships, Vinton County, were not thoroughly examined, but in the area covered the conglomerate was either wanting or thin and sandy. In most of the area the Sciotoville clay lies close to the Logan sandstones, showing a pronounced disconformity. The length of the deposit from southern Scioto County to Northern Jackson County is approximately 30 miles, and its form is tongue shaped, with the point south. Drill records show that there are other lobes or sheets of Sharon conglomerate east of this area under heavy cover, but the tests are too widely scattered to define the limits of the beds.

Special Features

The effects of the Sharon conglomerate on the topography of the region are also of interest. In the western part of the county, where the conglomerate is very thick, and especially where it is well above drainage, the ridges are unusually wide; the areas above the conglomerate are rather level, or only moderately rolling. Many good upland farms are located on these ridges.

In this region the valleys are usually narrow, and in many cases very gorge-like, conspicuously so along the headwaters of the small laterals. The high cliffs on the points of the hills along Pigeon Creek, north of Limerick, are attractive features of the topography. Along Poplar Run the weather resisting conglomerate forms long lines of projecting cliffs. Big Rock, an isolated point which is over 200 feet in height, and which is composed of Sharon conglomerate, is one of the special features of western Liberty Township.

Economic Value.

But little use has been made of the pebbly part of the Sharon conglomerate. The crushed rock and the somewhat washed and sorted gravel found in the beds of the streams are used locally for road work. Where used for a facing it requires some time to become thoroughly packed, but it then forms a good road which lasts for several years, especially where the traffic is not heavy. It is used only in the western part of the county where this material is at hand, and where the limestone is obtained only by transportation. The quartz pebbles, cleanly washed, finely crushed, and properly sized, will make excellent abrasive material for sand blasts, and for other purposes where sharp cutting edges are desired. It is used in concrete work by simply crushing the soft conglomerate and then mixing with cement. The amount of coarse gravel in the deposit is small, so the usual method practiced is to use crushed limestone for the coarse material and then enough sand and gravel with cement to fill the voids between the stone. For the best results the sand and gravel should be separated and then proportioned to the proper amounts, as one or the other is generally in excess. The use of the Sharon conglomerate for concrete is restricted to small pieces of local work, as the thick beds of clean loose gravel and sand along the Scioto River are available. An attempt was made to use the gravel for silica brick by crushing and bonding, but the results were not satisfactory, as the gravel is hard and thus required considerable grinding to reduce it to the proper fineness. Further, it carries considerable iron as a surface coating.

Near Jackson, and along Pigeon Creek north of Coalton, the Sharon conglomerate is a sandstone with but few pebbles, and is worked for local use and shipment. On land of the Star Furnace Company in Section 24, Liberty Township, sand is prepared for railroad shipment. The deposit worked at this place is about 45 feet in thickness. The sandstone is loosely cemented and contains only scattered quartz pebbles. The material is shot loose, crushed while fresh with sledges and shovels, and then screened. The sand is shipped over the Detroit, Toledo & Ironton Railway for foundry and other general purposes.

Another mine is operated by George Palmer on land of S. G. McKittrick, one mile north of Jackson. This deposit is 60 feet in thickness, very massive and contains practically no pebbles. The sandstone in the lower part of the deposit is quite pure. It is light colored, quite free from iron oxides, mica or argillaceous material, and was used at one time by the glass plant at Jackson. The upper part of the deposit is stained more or less with iron oxides, and near the upper surface contains some clay. The sandstone is quarried by blasting and then pulverized by hand. It is sold for general molding and foundry purposes, pig-bed sand, and for use in setting brick. Mr. Palmer states that he employs three men steadily. It is also worked in a small way just west of Jackson along the switch to the plant of the Jackson Iron & Steel Company. It has been worked at some time at other places in this region, but only in a small way.

The most important mine of this type in the county at present is that of the Jackson Sand Mining Company in Section 20, Washington Township. The Sharon conglomerate here is also a sandstone with but few pebbles. Above this, and separated from it by a thin clay, which is close to the horizon of the Sciotoville clay member, is found another sandstone stratum. Both are worked. Mr. E. B. Mathews, president of the company, reports as follows:

> The Jackson Sand Mining Company owns and operates sandstone quarries in Washington Township, Jackson County, Ohio. The part worked consists of two strata of sandstone. The lower stratum, measuring from the level of the valley, is 50 feet in thickness, while the upper one varies in thickness from 20 to 25 feet. There is a difference in the texture of the two, the lower one being coarser grained. The two deposits are separated by a thin stratum of soft fire clay. In both, the rock is made up of quartz sand, with only a small amount of cementing materials. The sandstone is drilled by compressed air drills and shot with powder, after which it is then selected, crushed, and sized, ready for the market. The power plant consists of one horizontal tubular boiler, one engine and one air compressor. The crushing plant consists of one crushing mill with hoisting drum, small steel cars, etc. The plant is

located on the Wellston and Ironton division of the Cincinnati, Hamilton & Dayton Railway. Two grades of sand are produced, distinguished by color as white and light yellow. The products have a wide reputation as molding sands for steel and iron castings and other foundry uses. This plant has been in continuous operation for twenty years.

SHARON, JACKSON SHAFT, OR No. 1 COAL

The next member above the conglomerate is the Sharon coal, which is the lowest workable bed found in the state, and which is well developed only in a limited area in Jackson County. The existence of the "Shaft coal" was first revealed by boring for brine at the time salt was made at Jackson.[1] Although discovered in 1863, and soon afterwards opened and mined, the deposit is not yet exhausted, but the best of the field is gone. See Map I.

Stratigraphy and Area

The Sharon coal lies either directly on or only a few feet above the Sharon conglomerate when both are present. In many places the conglomerate is found with no coal above, while at other places the coal is present with no conglomerate below. Starting in the southern part of the county the stratum will be traced northward.

Hamilton Township.—In Hamilton Township only traces of the Sharon coal were seen. Its absence in the eastern half of the township along the Little Scioto River and Holland Creek is due evidently to the Mississippian strata remaining a land mass during the deposition of this coal. This point has been discussed under Mississippian series. In the western part of the township the Sharon conglomerate is found in massive beds, but no coal was seen above it. The strata here resting on the conglomerate are those higher in the scale than the Sharon coal. Whether this is due to a disconformity, or to a lack of deposition owing to unfavorable conditions, was not determined, but apparently this condition results from the former cause.

Scioto Township.—In the southern part of Scioto Township the conditions are somewhat similar to those in western Hamilton. On Sugarcamp Creek, just west of Grahamsville, the Sciotoville clay, part a true flint, was seen in the bed of the stream, and only a short distance farther down the Sharon conglomerate was well exposed. The interval, measured by the aneroid, from the conglomerate to the clay is only 20 feet, and although covered here no coal was observed above the conglomerate at other places where the conditions were more favorable. In Section 28, near the road to Shinar School, and just south of Jacko Run, the dark shales, associated with the Sciotoville clay, and only about 10 feet above the conglomerate, are exposed in the bed of a small stream. The flint clay, with the associated black shales on this horizon, was seen about three-fourths of a mile north on

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[1] Geol. Surv. of Ohio, Report, 1870, p. 147.

the land of Harvey Gahm. In Pigeonroost Hollow, Section 34, on the land of William Engle, clays and dark shales, similar to those seen at Grahamsville, except that no flint clay is present, were found lying directly on the Sharon conglomerate. Thus in this part of Scioto Township the Sharon coal is apparently absent, and the conglomerate lies close to the Sciotoville clay. In the western part of the township the Sharon coal is generally wanting, but in a few localities it is represented by thin coal or carbonaceous shales.

South of Cove the Sharon coal is present. On the lands of Fred Flaker and William B. Pratt the Sciotoville flint clay has been worked. Below this bed the stain of the Sharon coal was found, which, across the hollow to the east, shows on the outcrop a thickness of 3 feet. A section here is as follows:

	Ft.	In.
Clay, flint, *Sciotoville*, reported thickness	2	--
Sandstone	2	--
Shales, and covered	35	--
Coal blossom, *Sharon*	1	--
Covered	18	--
Conglomerate, *Sharon*	24	--

The strata are well exposed up the road from Buckeye Creek to the top of the ridge north in sections 11 and 2, but no trace of the Sharon coal was seen. The rocks exposed are as given below:

		Ft.	In
Flaggy sandstone layers in shale, irony	*Jackson Sand Block* ore horizon	7	--
Covered		5	--
Sandstone, irony		1	--
Shale		7	--
Sandy shale and thin flaggy sandstone		12	--
Sandstones with ore nodules		2	--
Shale, sandy		3	--
Covered		4	--
Sandy shale and thin flaggy sandstone		18	--
Covered		16	--
Clay, plastic, *Sciotoville*		3	--
Shale, sandy		2	--
Covered		10	4
Sandstone, with small ore nodules		--	8
Shaly sandstone		5	--
Shale		10	--
Conglomerate, *Sharon*		6	--

The conglomerate goes under cover near where the pike crosses Buckeye Creek. A thin black shale, which probably marks the horizon of the Sharon coal, was observed here just above the conglomerate. In the hills northwest of Cove the Sharon coal thickens and is quite persistent. In Section 6, on the property of J. C. Farrell, the bed has been opened and worked, but the coal was not seen when the place was visited. The thickness reported is 2 feet, 9 inches, but no section was obtained. In Section 7, on the Sawyer property, the coal is being worked at present (1914), and the section obtained is as follows:

	Ft.	In.
Ore, with pebbles, *Guinea Fowl*	--	6
Covered	5	--
Coal stain	--	2
Clays, plastic, upper part siliceous, lower part "pink eye," *Sciotoville*	13	8
Sandstone, massive	11	--
Shale	13	6
Coal, *Sharon*	2	6
Covered	14	--
Conglomerate, *Sharon*	16	--

In the northwestern corner of Section 6, on the Robert Lamb property, the Sharon coal, the Sciotoville clay, part a true flint, and the Sharon conglomerate are all exposed. The following section was taken at this place:

	Ft.	In.
Clay, flint and semi-flint, good quality, *Sciotoville*	6	--
Covered, barometer measurement	32	--
Sandstone, massive	5	--
Coal, *Sharon*	2	4
Covered	10	8
Sandstone, massive } *Sharon*	10	--
Conglomerate }	16	--
Covered	10	--
Sandstone, *Logan*.		

Near Mountain Ridge Cemetery in Section 6, on land of Joseph West, a heavy blossom of bony Sharon coal was seen near the level of the road, while on the hill above, the outcrop of the Sciotoville clay is exposed. The clay is part flint and part "pink eye" or ferruginous clay. The section measured follows:

	Ft.	In.
Clay flint and ferruginous plastic, *Sciotoville*	5	--
Covered	45	--
Coal blossom, *Sharon*	4	--
Conglomerate, *Sharon*	5	--

Liberty Township.—The Sharon coal is very persistent in Liberty Township as the bed is represented in nearly every section. Although it has been mined in a large way for railroad shipment along the preglacial valley west of Jackson, and in a small way for local needs in parts of the remaining territory, there are yet large quantities of this fuel available for future use. In fact the best areas of Sharon coal in Jackson County now known are in Liberty Township. The coal is generally of good quality, and at many places the deposit is of sufficient thickness for ease and economy in mining. This field will now be described in more detail.

In Section 36, Liberty Township, on the land of Charles Edward, the coal is being mined at present, and the section obtained is as follows:

	Ft.	In.
Shale	12	--
Coal, *Sharon*	2	7

On the land of E. G. Swan, just north of the above, where the coal has also been worked, the bed is reported 30 inches in thickness In Section 25, west, the Sharon coal is thin or wanting, and in Section 31 the exposures noted indicate the same conditions. The blossom of the coal was seen at a few points in Section 30, but the surface exposures indicate that the deposit is made up largely of bony shales. The following section was taken on land of David Hively near the head of Buckeye Creek:

	Ft.	In
Sandstone, with parts covered. The sandstone is made up of coarse-grained sand and fine pebbles	70	--
Covered	3	--
Coal blossom, *Sharon*, reported thickness	3	--

The coal is reported to be shaly.

The coal is also reported near Bethel Church on land of D. N. Rutledge. On land of J. W. Apple, in Section 32, the bed has been opened, but is reported shaly. An exposure along the road in the northern part of Section 29 shows the character of the Sharon coal here, and its relation to other members. The following measurements were taken:

	Ft.	In.
Coal, shaly, *Sharon*	2	6
Clay, light, plastic	4	--
Covered	8	--
Conglomerate, pebbly, *Sharon*	35	--

In the eastern part of the same section the coal is of good quality and is worked for local use. A section taken on land of David C. Jones is as follows:

	Ft.	In.
Sandstone, shaly, blue	3	--
Shale	--	10
Coal, good, *Sharon*	2	10
Covered	10	--
Conglomerate, *Sharon*	30	--

Here the bed shows irregularity of deposition as it dips some 15 feet in a short distance and then rises again to about the original level. The coal has much the same thickness throughout, but is generally somewhat heavier in the trough. Coal is mined for local use on land of Oscar Behem in Section 28. The bed is reported thick, but part somewhat shaly. At the mines of the Jackson Decatur Coal Company the section obtained is as given below:

	Ft.	In.
Ore, nodular, siliceous, irregular, *Sharon*	--	6
Shale, blue	2	6

	Ft.	In.
Coal, good Coal, bony } *Sharon*	2 --	11 4
Clay	1	--
Conglomerate, *Sharon*.		

In Section 24, on the land of the Star Furnace Company, and at the sand mine of Samuel Eubank, the following section was taken:

	Ft.	In.
Shale	6	6
Coal, reported thickness, *Sharon*	2	6
Sandstone, with a few pebbles at top, and occasional pebbles in that below, *Sharon* conglomerate equivalent	45	--

One-half mile north of the above, but just east of Salt Creek, on the land of Edward Smith, the Sharon coal is mined at present (1914). A section here is as follows:

	Ft.	In.
Shale	12	--
Coal, *Sharon*	2	10
Covered	2	--
Conglomerate, with many pebbles, *Sharon*	80	--

Just east of this, on the property of David Nicholls, the Sharon coal has been worked just below his house, and the Quakertown on the knob to the northeast. A section here is as follows:

	Ft.	In.
Shale	10	--
Coal, *Quakertown*, reported thickness	2	6
Covered	24	--
Sandstone, massive	33	--
Covered	5	--
Shale, and covered	19	4
Coal, *Sharon*, reported thickness	2	8
Covered	2	--
Conglomerate, *Sharon*	40	--

This section is important as both coals, separated by an interval of 81 feet, and the Sharon conglomerate below, are shown. At the Armstrong mine in Section 26 the strata measured are as follows:

	Ft.	In.
Shale, dark	21	--
Coal, *Sharon*	2	6
Shale, dark, carbonaceous	3	--
Conglomerate, *Sharon*	40	--

South of the above, in Section 35, a record taken along the road east of the old Hammertown mine is as given below:

	Ft.	In.
Coal blossom, *Vandusen*	--	6
Shales	16	--
Ore, *Jackson Sand Block*, seen on Johnson farm	5	6
Sandstones, flaggy, with parts covered	16	6
Sandstones, thin-bedded, shaly	10	--

	Ft.	In.
Coal blossom.		
Clay, plastic	4	--
Covered	30	--
Sandstones, part shaly, thin-bedded	12	--
Shales and covered	21	--
Coal, *Sharon*, reported thickness	2	6

A roll or sudden dip of about 21 feet of the Sharon coal occurs at this place. East of this line the coal is thick and has been mined, while west of this it is shaly and thin. The next section in the hollow to the south of Hammertown mine, where the Sharon coal is represented by a thin black shale with a few inches of coal, thus shows this condition. A section from the coal to the Jackson Sand Block ore, on the point just north of the Korn mine, is as follows:

		Ft.	In.
Ore, *Jackson Sand Block*		1	--
Covered		71	--
Sandstone, massive		12	--
Covered		18	--
Sandstone, massive		12	--
Sandstone, with ore nodules and finger coal	*Sharon* coal horizon	1	--
Sandy shale		--	10
Coal		--	2
Shale, dark, carbonaceous		--	6
Clay shale, dark		1	--

In the hollow just west of Pleasant Grove Church, Section 26, the coal has been mined, but no section was obtained. East of this a section, taken along the road from the property of John Scurlock to the church, is as follows:

	Ft.	In.
Covered, *Jackson Sand Block ore horizon*	20	--
Sandstone, flaggy	5	--
Covered	20	--
Ore, kidney	--	--
Shale, with parts covered	48	--
Sandstone	11	--
Covered	12	6
Sandstone	13	--
Shale, dark blue	8	6
Coal, *Sharon*, reported broken and thin	1	--

The line of dip from the Hammertown mine passes through this point and was seen in the creek bed southwest of the house. At the abandoned Decatur No. 2 mine the following strata were seen and measured:

	Ft.	In.
Ore, siliceous, with pebbles, *Guinea Fowl*	--	11
Covered	4	--
Sandstone, with occasional pockets of pebbles	23	--
Covered	9	--
Coal, *Sharon*, reported thickness	3	--
Covered	5	--
Sandstone, with some pebbles, *Sharon*	30	--

In Section 13, on land of Louis Ray, both the Sharon and Quakertown coals were exposed in the same hill. The Sharon coal here was formerly mined by the Star Furnace Company, and is reported to have a thickness varying from 2 feet 10 inches on the north side of the hill to 4 feet on the south side. The Quakertown coal, lying close to the summit of the hill, is reported, where opened, to be 2 feet 6 inches in thickness. At the point where the section was taken the Sciotoville clay lies on the Sharon coal, but at another point there was 5 feet of shale and sandstone intervening. Miners reported that in some places in the mines the clay lies directly on the coal. The Sharon coal here is reported to be irregularly deposited showing many dips and rolls. The section measured is as given below:

		Ft.	In.
Coal, *Quakertown*		2	6
Covered		58	--
Sandstone		10	--
Clay, flint	*Sciotoville*	1	2
Clay, plastic		1	10
Coal blossom, *Sharon*		1	--
Clay, dark, siliceous		2	--
Conglomerate, *Sharon*, upper surface very irregular		91	--

At the Sunshine mine, in Section 23, the Sharon coal is reported to have an average thickness of 2 feet 6 inches and to be quite steady in volume. The bed lies close to the underlying Sharon conglomerate and has shales for the roof material. The Sharon coal was not found in good thickness in Section 14, and in part of the region it appears to be completely wanting. It has been worked in a small way at a few places in Section 22. On land of John Cogar the following rocks were exposed:

	Ft.	In.
Coal, *Sharon*, reported thickness	2	--
Covered	5	--
Conglomerate, *Sharon*	30	--

On land of Washington Johnson coal is mined for local use. The bed is reported by Mr. Johnson to average about 2 feet 3 inches in thickness, and the fuel to be of good quality. In the northeastern corner of the section, on land of W. M. Overly, the deposit has excellent thickness, ranging from 2 feet 6 inches to 4 feet, and the quality of the coal is very good. The section measured is as given below:

	Ft.	In.
Coal, *Sharon*	3	--
Covered	6	--
Conglomerate, *Sharon*	50	--

In a part of Section 21, Liberty Township, the Sharon coal has good thickness and has been worked for local use for many years. In the southwestern part of the section, on land of P. C. White, the thickness of the coal measured in a mine is as follows:

	Ft.	In.
Shale, soft	--	5
Coal, *Sharon*	2	4
Covered	20	--
Conglomerate, *Sharon*	10	--

North of this, on land of T. L. Bennett, the coal has been opened by entry. Mr. White reports the thickness of the bed where opened to be 1 foot 8 inches. Here below the coal there is a siliceous, flinty clay, much resembling that on the Sciotoville clay horizon. On land of James Bryan mines have been operated for many years. The coal is of exceptionally good quality and has excellent thickness, but lies somewhat irregular. A section taken near the head of the entry with measurements of the strata below the coal, which were exposed on the hill to the west, is as follows:

	Ft.	In.
Sandstone, with fine pebbles	8	--
Coal, good, *Sharon*, about average thickness	3	6
Clay and argillaceous sandstone	2	--
Conglomerate, *Sharon*	25	--

This deposit has also been mined in a small way in the northeastern part of the section on land of William Yerian and Margaret Coyl. On the Yerian property the coal is reported to vary in thickness, from 2 feet 4 inches to 3 feet and to average about 2 feet 6 inches, while on the Coyl property it is reported to vary from 2 feet 4 inches to 3 feet 6 inches and to average more than 2 feet 6 inches. A section taken at the mouth of an old mine is as follows:

	Ft.	In.
Coal, *Sharon*	2	6
Clay, part flinty siliceous	3	--
Conglomerate, *Sharon*	30	--

North of this in Section 16 the coal has been opened in a few localities. It appears to thin somewhat in its extension northward, but to be quite persistent. The following measurements were made near the mouth of a new mine on land of Albert Harper:

	Ft.	In.
Shale, sandy	2	--
Coal, *Sharon*	2	3
Clay, flinty	1	--
Covered	7	--
Conglomerate, *Sharon*	60	--

North of this, on land of Samuel White, the following rocks were exposed:

	Ft.	In.
Shale	--	3
Coal, *Sharon*	2	2
Clay, dark blue, plastic	1	--

	Ft.	In.
Covered	8	--
Conglomerate, pebbly, *Sharon*	110	--

The rocks seen and reported on land of Orland Grover, in Section 20, are as given below:

	Ft.	In.
Shale	1	--
Coal, *Sharon*	2	4
Conglomerate, *Sharon*, very thick, seen on knob.		

The coal in this locality has been mined for local use. It has also been mined at a number of places in Section 17, where it generally has good thickness. In the eastern part of the section, on land of W. S. Greene, the thickness of the deposit near the outcrop is shown by the following measurements taken at the mouth of a new mine:

		Ft.	In.
Shale		1	6
Coal	*Sharon*	4	--
Coal, bony		--	2
Clay		3	--
Conglomerate, *Sharon*, very thick, not measured.			

North of this the coal is worked for local use on land of Wm. Landrum. The bed varies in thickness from 3 to 4 feet, but is reported to average 3 feet 4 inches. It is irregularly bedded as it conforms to the wavy surface of the conglomerate below. The section taken here follows:

		Ft.	In.
Shale, blue, sandy		2	6
Coal, good	*Sharon*	3	9
Coal, bony		--	3
Covered		2	--
Conglomerate, *Sharon*		80	--

At another opening the following relations were seen:

	Ft.	In.
Sandstone, ferruginous, with both fine and coarse pebbles	11	--
Coal, *Sharon*	3	1
Covered	19	--
Conglomerate, *Sharon*, very thick, not measured.		

At this place, as shown above, the coarse-grained sandstone lies on the coal, while at the other mine there is 2 feet 6 inches of shale intervening. In the southern part of the same section, on land of John S. Grover, the coal, seen on the outcrop, and the associated rocks are as follows:

		Ft.	In.
Shale		4	--
Coal, good	*Sharon*	2	3
Coal, somewhat bony		1	--
Covered		2	--
Conglomerate, *Sharon*		100	--

In the northern part of the section, on the property of Walter Coy, the Sharon coal was at one time mined in a small way for local use. The thickness reported is from 2 feet 6 inches to 2 feet 8 inches. The section taken there follows:

	Ft.	In.
Shale	5	--
Coal, *Sharon*, reported thickness	2	6
Clay	1	6
Conglomerate, *Sharon*	145	--

From surface indications the Sharon coal in Section 19 is generally thin and in places wanting. In Section 18 it is somewhat thicker, but rather uncertain. A composite section which shows the relation of the coal to the rocks above and below was taken along the road in the southwestern part of the section, and is as follows:

	Ft.	In.
Shale	10	--
Coal blossom, *Sharon*	--	6
Clay, sandy	2	6
Conglomerate, *Sharon*	102	--
Covered	10	--
Sandstones and shales, *Logan*	65	--

South of the above, on land of Mary J. White, the coal was opened and the section obtained follows:

	Ft.	In.
Sandstone	3	--
Coal, good, *Sharon*	2	2

In the central part of the section, on property of Herbert Vance, the Sharon coal was exposed for measurement. The section recorded is as given below:

	Ft.	In.
Sandstone, with coarse and fine pebbles, and parts covered	45	--
Coal, *Sharon*, thickness reported	2	--
Covered	12	--
Conglomerate, *Sharon*	60	--

Wm. Ragland reports that on his property 2 feet of coal was found when digging a well. The coal lies close to the conglomerate, about 90 feet of which is exposed. The following measurements were obtained on land of Belle Weese in the eastern part of the section:

	Ft.	In.
Sandstone, coarse-grained, lower part with both fine and coarse pebbles	75	--
Coal blossom, *Sharon*	2	--
Covered	9	--
Conglomerate, *Sharon*	30	--

From surface indications the Sharon coal is wanting or thin in most of Section 24, west. On land of Christopher Rapp the coal has been prospected and is reported to be about 1 foot in thickness. In

Section 13, west on the property of Rush Hartley, a section showing the coal, which is mined at present (1914), and the conglomerate, very thick and pebbly, is as follows:

	Ft.	In.
Shale, dark, tough	--	8
Coal, *Sharon*	2	6
Covered	6	--
Conglomerate, *Sharon*	105	--
Shales, *Logan*	10	--

On the main ridge in Section 1, west, the Sharon coal appears to be somewhat local. It was opened at one time on land of Neal Austin who reported the thickness to be about 3 feet 7 inches. The section taken at the mouth of the old mine is as given below:

	Ft.	In.
Sandstone, coarse-grained	10	--
Coal, *Sharon*, reported thickness	3	7
Clay, and covered	5	--
Conglomerate, *Sharon*	40	--

The coal areas in sections 6 and 7 are small, confined to a few high hills. In the southwestern part of Section 6 Sharon coal was formerly mined on land of W. M. Bailis. The section there follows:

	Ft.	In.
Sandstone, and covered	55	--
Coal, *Sharon*, reported thickness	3	--
Covered	6	--
Conglomerate, *Sharon*, massive, not measured.		

In the same section, just west of Pigeon Creek, coal was mined for local use on land of Green Bailis. The rocks exposed there gave the following measurements:

	Ft.	In.
Sandstone, coarse-grained, soft	35	--
Coal, *Sharon*, average thickness reported	3	--
Covered	2	--
Conglomerate, *Sharon*	40	--

The surface exposures indicate that the coal is wanting or generally thin is Section 5. On property of J. M. Vance, on the main ridge in Section 8, coal is mined for local use. The section taken there follows:

		Ft.	In.
Shale, blue		2	6
Coal, good	*Sharon*	1	8
Coal, bony		--	4
Clay, and covered		5	--
Conglomerate, *Sharon*		60	--

In sections 4 and 9 the coal is wanting or generally thin. In the central part of Section 4, on land of Clifford Mercer, the bed was formerly mined for local use. It is reported to be 1 foot 8 inches in thickness.

In Section 3 the prospects for coal are generally poor as it is shaly or thin. On land of A. B. Erwin the rocks exposed were as follows:

	Ft.	In.
Coal, shaly, *Sharon*	3	--
Conglomerate, *Sharon*	11	--
Sandstones and shales, *Logan*	70	--

In the southern part of Section 10, on land of B. Stevenson, the coal has been mined along the outcrop by stripping. It lies close to the conglomerate, which on the hill west measured 90 feet in thickness. The thickness of the deposit is reported to be 1 foot 6 inches. In the eastern part of the section the surface exposure shows the coal to be thin and shaly. On land of John Crossin the following measurements were made:

	Ft.	In.
Coal blossom, *Sharon*	--	6
Clay	--	8
Conglomerate, *Sharon*	105	--

From the evidence observed the Sharon coal is also thin or wanting in Section 11. Near the old Pine Hill School, on land of W. B. Steffy, the interval from the Sharon to the Quakertown coal was obtained. The measured section follows:

	Ft.	In.
Coal blossom, *Quakertown*	2	--
Clay shale	4	--
Sandstone, soft; part shaly	45	--
Sandstone, and covered	23	--
Sandstone, coarse-grained, with both fine and coarse pebbles, lower part ferruginous	13	--
Shales, dark, carbonaceous, *Sharon* coal horizon	3	--
Conglomerate, *Sharon*	110	--

The Sharon coal was not seen in any considerable thickness in Section 2. The interval from the Sharon coal to the Quakertown bed was also obtained here on land of D. D. Edwards. The record follows:

	Ft.	In.
Sandstone, shaly	3	--
Coal, *Quakertown*	3	6
Clay shale	1	6
Covered	42	--
Sandstone, ferruginous	2	--
Sandstone, ferruginous, with large pebbles, *Guinea Fowl* ore horizon	1	--
Clay, flinty, siliceous } *Sciotoville*	1	6
Clay, light, soft	10	6
Sandstone, and covered	23	--
Shale with thin ferruginous sandstones	5	--
Sandstone, shaly	5	--
Shale, blue	7	--
Coal, shaly, *Sharon*	--	4
Clay, blue	2	6

	Ft.	In.
Covered	4	--
Conglomerate, *Sharon*	90	--

In the northeastern part of the same section, on land of John Shay, the record obtained is given below:

	Ft.	In.
Shale, carbonaceous, *Sharon* coal horizon	--	5
Clay shale, dark	1	6
Covered	10	--
Conglomerate, *Sharon*	30	--

Where seen in sections 12 and 1 the Sharon coal was shaly or thin. In Section 12, on land of Isaiah Burnett, the following rocks were exposed:

	Ft.	In.
Coal, *Quakertown*	3	1
Clay	1	--
Covered	45	--
Sandstone	20	--
Shales, dark, carbonaceous, *Sharon* coal horizon	2	--
Conglomerate, *Sharon*	100	--

The following section, taken on land of James Wilson in Section 1, shows much the same conditions as that above:

	Ft.	In.
Coal, *Quakertown*	3	1
Clay	1	--
Covered	16	--
Sandstone	18	--
Covered	40	--
Coal blossom, *Sharon*	--	3
Covered	25	--
Conglomerate, *Sharon*	45	--

Lick Township.—In Lick Township the Sharon coal reaches its maximum thickness in the basin under Jackson where it has been worked for 50 years. The following section was taken at the mine of the Jackson Iron & Steel Company:

	Ft.	In.
Coal	--	6
Clay, plastic, good	3	--
Covered	63	--
Shale	30	--
Coal, 2 to 6 inches slate band in center, *Sharon*	3	3
Shale, dark, sandy	2	10
Sandstone, *Sharon*	8	--

At the head of the west entry the thickness is 31 inches, and at the head of the north entry 33 inches. The dip east, according to the mine foreman, is 19 feet in 2,300 feet, or about 44 feet to the mile. Near the mouth of the shaft the coal suddenly dips eastward at a high angle, but, as the old works were filled with water, the amount of this was not obtained. From this mine the roll runs northward and then eastward to

Salt Creek. Core drill records, kindly furnished by this company, show that westward from the shaft the coal holds good thickness, as it was from 3 feet to 3 feet 3 inches. In Section 31, south of this, a test made on the ridge near John Mapes' house shows the coal to be wanting.

In the hollow just east of the furnace a section of an air shaft, on the land of the Jackson Iron & Steel Company, and of the hill to the north, is as given below:

	Ft.	In.
Ore, *Jackson Sand Block*, thickness reported	2	--
Shales, sandy	10	--
Sandstones, flaggy, with parts covered	36	--
Covered	4	6
Coal, cannel, bony	--	6
Covered	2	--
Top of air shaft.		
Shales and shaly sandstones	59	6
Coal, *Sharon*, reported thickness	3	6

At the mine of Charles Booth, just west of Jackson, the section is as follows:

	Ft.	In.
Shale	10	--
Coal, *Sharon*	3	6
Shale and shaly coal	1	--
Sandstone, with pebbles at top, *Sharon*.		

The sandstone rises to the coal in places. In the isolated hill just north of this the coal rises fast and thins or goes out in the sandstone, as it is not found in the northern part, but has been worked in the southern part facing the Booth mine. This is a continuation of the roll noted at the mine of the Jackson Iron & Steel Company. The sandstone on this hill continues westward into the northern part of Section 25, Liberty Township, but here also no coal is found above it. Boone Rock, and the sandstone cliffs east of Salt Creek, are evidently a part of the same formation. In a small territory here the coal is thin or wanting, but appears to the west in Section 24, Liberty Township, on the land of the Star Furnace Company, and north in Section 13, Liberty, on the lands of Edward Smith and David Nicholls, sections of which have been given. In Section 20, Lick Township, on the land of S. G. McKittrick, the Sharon coal, although thin, is again found. This coal lies directly above a heavy sandstone that can be followed directly to Boone Rock just north of Salt Creek. The sandstone below the coal south of Salt Creek is evidently a continuation of this, as it agrees in texture and appearance, and it is seen also in the bed of the stream, thus apparently crossing the valley. The section on S. G. McKittrick's land is as follows:

	Ft.	In.
Ore, with pebbles, *Guinea Fowl*	--	4
Shales, and covered	34	--
Coal, *Sharon*, reported thickness	1	8
Sandstone, *Sharon*	50	--

It thus appears that the roll noted at the shaft of the Jackson Iron & Steel Company continues northward and crosses Salt Creek in this vicinity, and agrees with that found by Orton and Andrews, which is as follows:[1]

> On the land of Mr. McKittrick, lot 44, Lick Township, we find a seam of coal which is evidently the same as the lowest seen at the "Pine Tree Hill" on Charles Walden's land, not far from Buffalo-Skull Creek. It rests upon a coarse white sand-rock, with well marked conglomerate at the top. This rock constitutes the ledge seen a half mile north of Orange Furnace. This ledge is forty feet in height. So far as we could learn, no seam of coal has ever been found below the white sand-rock. Mr. McKittrick once opened a bank and mined a little of his coal, which he reports to be 1 foot 4 inches in thickness of seam. About 200 yards from the opening spoken of, and in a northwest direction, we found another old coal entry, the elevation of which showed that the dip of the coal seam in that short distance is 10 feet. No sample of the McKittrick coal could be obtained for examination, but I have no doubt that it is the geological equivalent of the "Shaft seam." The rapid dip seen between the two points on the McKittrick's land would take the seam below the surface of the valley at the town of Jackson. By examining an exposure of the strata along the bank of Salt Creek, between the bridge on the Chillicothe road and the "old mill" in the town, it is found that the shales, including a very thin seam of coal, all dip uniformly in a southern direction. If the data given us respecting the depth of the shaft coal near the bridge obtained by boring, and at the "old mill," in the shaft, are to be relied upon, the coal has dipped about 15 feet towards the latter point. The reports give the increase of thickness of the coal seam from 1 foot 8 inches at the bridge to 3 feet 4 inches at the mill.

In Section 17, on the side of the pike just south of Mrs. J. G. McKittrick's house, was seen the thin blossom of a coal with some bluish clay below, which is on about the same level as that on the S. G. McKittrick farm, and thus on the Sharon horizon. The Quakertown coal here has been mined on the hill, and the interval between the two beds is about the same as that on the Nicholls land in Section 13, Liberty Township. The section seen is as given below:

	Ft.	In.
Ore, kidney	--	4
Shales, and parts covered	25	--
Coal, *Quakertown*, reported thickness	2	6
Covered	8	6
Sandstone, shaly	5	--
Sandstone, massive, small parts covered	49	--
Covered	20	--
Dark shales and bluish clay, *Sharon* horizon	2	6

The Sharon coal horizon can be traced northward from the S. G. McKittrick farm into the southeast corner of Section 18, where the thin stain with clays below may be found in a number of places along the pike. The main basin of the Sharon deposit is under Jackson, but the available coal here has been practically all taken out. The thickness of the bed in the old slope, and three shafts formerly worked, is taken from the early reports.[2]

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[1] Geol. Surv. of Ohio, Report, 1870, p. 147.

[2] Geol. Surv. of Ohio, Report, 1870, p. 148.

The slope was excavated by Messrs. Kyle, Brown & Co. It reveals the following strata:

	Ft.	In.
Soil, and not seen	7	--
Sand-rock	15	--
Blue sandy shale	8	--
Coal	2	11

The coal is probably thicker in other places in the mine.

Orange Furnace shaft:

	Ft.	In.
Sand-rock	6	--
Coal	--	3
Conglomerate	1	--
Coal	--	6
Sand-rock	2	--
Compact blue shale	25	--
Coarse sand-rock	10	--
Blue sandy shale, with coal plants	10	--
Coal	4	1

The coal seam in this mine is very uneven. In one place the coal is said to dip 30 feet in a very short distance.

Star Furnace shaft:

	Ft.	In.
Clay shale	15	--
Blue sandy shale, compact and containing coal plants	20	--
Black slate	--	4
Coal, probable average	3 to 4	--

In this mine the coal seam is reported to be very undulating.

Fulton Furnace shaft:

	Ft.	In.
Clay shale	1	6
Coarse sand-rock	15	--
Sandstone, hard and laminated	48	--
Soft sandy shale, rich in coal plants	10	--
Coal	2	5
Fire clay and black slate	6	--

In Section 28 the record of Globe Shaft, which is in operation at present, is as follows:

	Ft.	In.
Alluvium	42	--
Clay, sandy	3	--
Shale	10	--
Clay, sandy, light	5	--
Shale, sandy	50	--
Coal, *Sharon*	3	8

No records were obtained in regard to the coal south and east of this although the territory has been drilled.

Coal Township.—The Sharon coal, although thin, is found in a number of places in Coal Township. In Section 7, on the land of Charles

Exline, it has been opened and worked for local use. The bank had fallen in when visited, but the thickness of the coal is reported as follows:

		Ft.	In.
Shale, black		--	6
Coal, cannel, poor	*Sharon*	--	2
Coal, good		1	5
Clay, dark blue, sandy		4	--
Conglomerate, *Sharon*		35	--

Just north of this, on the land of Louis Mapes, it is present also, and on the hill to the west both the Sciotoville clay, a true flint of good quality, and the Quakertown coal were found. A measured section is as given below:

	Ft.	In.
Shale	10	--
Coal, reported thickness, *Quakertown*	3	--
Shale and covered	38	--
Clay, flint, *Sciotoville*, reported thickness	3	--
Covered	21	--
Sandstone, with a few pebbles in places	27	--
Coal blossom, *Sharon*	1	--

At this place the two coals are separated by the Sciotoville clay, which is found above the Sharon coal in the western part of Liberty and Scioto townships. On the hill just south of Bierlytown, on the land of Arthur Howe, the following strata were seen:

	Ft.	In.
Shale	15	--
Coal, reported thickness, *Quakertown*	1	3
Covered	31	--
Sandy shales and thin shaly sandstones	13	--
Clay, flint and semi-flint, good quality, *Sciotoville*	5	--
Covered	9	--
Sandstone, massive	11	--
Shales	3	--
Black shales, and covered, *Sharon coal horizon*	8	--
Clay, light, sandy	5	--
Covered	37	--
Conglomerate, *Sharon*	25	--

The horizon of the Sharon coal is above drainage along the stream courses in the western part of sections 6 and 7, along that of Pigeon Creek, north of Coalton, and possibly in the northwestern part of Section 30, Coal Township. Where exposed the deposit is thin, or it is made up of bony coal and dark carbonaceous shales. In Section 6, on land of C. W. Haslett, 2 feet 6 inches of dark carbonaceous clay shales, representing the Sharon coal, were found in the bed of the small stream. There is a roll of some 32 feet in the Sharon conglomerate here and these shales lie in the trough of the roll. Near the mouth of the hollow the conglomerate is about 70 feet in thickness. At one place above it dark carbonaceous shales were also observed.

A composite section taken from the hill just west of Jacob Sell's home, in Section 32, to the bed of the stream west, shows the intervals from the Lower Mercer limestone to the Quakertown coal, and from this to the Sharon coal. The section measured follows:

		Ft.	In.
Limestone, *Lower Mercer*		--	8
Shale, and covered		130	--
Coal, *Quakertown*		2	8
Covered		70	--
Sandstone		2	--
Bone shale, black		1	2
Coal, bony	*Sharon* coal, equivalent	--	5
Clay shale, dark, carbonaceous		1	5
Coal, bony, with thin shale partings		--	6
Clay, siliceous, upper part dark		5	6
Sandstone, *Sharon* conglomerate, equivalent		5	--

Washington Township.—In Washington Township the horizon of the Sharon coal is above drainage along the valley of Pigeon Creek, and for some distance up the valleys of its main tributaries. In a part of this region both the Sharon coal and Sharon conglomerate are wanting; the heavy sandstone above the coal horizon lies directly on the Logan sandstone below. At Glen Nell and near Primrose School small local pockets exist in which the coal is of workable thickness. In other localities a thin or shaly blossom of the member was seen. At the old Glen Nell mines, in Section 20, the following record was obtained:

	Ft.	In.
Sandstone, with parts covered	80	--
Coal, *Quakertown*, reported thickness	2	--
Shales, and covered	74	--
Coal, *Sharon*, reported thickness	3	--
Covered	3	--
Conglomerate, *Sharon*	15	--

At the mouth of an old mine east of this the structure of the bed exposed was as follows:

	Ft.	In.
Ore, *Sharon*, siliceous, with pebbles in places, fossiliferous and irregular in thickness	--	7
Shale, dark, carbonaceous	--	4
Coal, *Sharon*	3	1

Mr. O. C. Sells, who operated the mines here, reports that the coal varies in thickness from 2 feet 8 inches to 5 feet, and that in places part of the bed was cannel which had a maximum thickness of 2 feet 6 inches. He reports the thickest coal at this place is worked out, but that there is yet an area of thin coal.

A composite section, approximately accurate, and covering nearly the entire thickness of the Pottsville, taken eastward from Glen Nell to the point near the Town House, near the line of sections 21-22, gives an idea of the relation of some of the important members. The section follows:

	Ft.	In.
Black flint, just below horizon of Brookville coal	1	--
Shale, and covered	18	--
Shale	3	--
Coal blossom, *Tionesta*	1	--
Clay, sandy	2	--
Sandstone, soft, micaceous	37	--
Covered	14	--
Shale, dark blue	6	--
Coal, *Upper Mercer*	1	--
Shale, dark, carbonaceous	3	--
Shale, sandy	8	--
Covered	4	--
Sandstone	12	--
Ore, *Lower Mercer*	--	--
Covered	75	--
Sandstone	5	--
Coal, irregular, wanting in places, probably part of *Quakertown*	--	6
Sandstone	3	2
Sandstones and sandy shale	3	6
Coal, *Quakertown*, very irregular, with sandstone cutting into it	2	6
Shale, and covered	61	--
Sandstone, coarse-grained	12	--
Ore, *Sharon*, with pebbles, fossiliferous	--	7
Shale, dark, carbonaceous	--	4
Coal, *Sharon*	3	1
Covered	3	--
Conglomerate, *Sharon*	15	--

The Sharon coal has been mined for local use on land of W. M. Muncy in Section 16. The Sharon conglomerate is wanting here, hence the coal lies close to the Logan sandstones. The section obtained follows:

		Ft.	In.
Pottsville formation.			
Sandstone, cross-bedded, coarse-grained		15	--
Shaly sandstone and sandy shales		20	--
Coal, *Sharon,* cannel nature, part somewhat bony		2	--
Clay shale, light, siliceous		2	--
Shale, sandy		6	--
Covered		12	--
Logan formation.			
Sandstone		5	--
Conglomerate	of *Allensville* member	1	--
Sandstone		--	6
Conglomerate		--	5
Sandstone		--	4
Conglomerate		--	7
Sandstone		4	--

At another opening the rocks exposed were as given below:

	Ft.	In.
Shale, and covered	18	--
Sandstone, cross-bedded	25	--
Disconformity	--	--
Shale, sandy	6	--
Ore, Sharon, with pebbles, fossiliferous	--	6
Shaly sandstone and sandy shales	14	6
Coal, *Sharon*, part bony	2	--

Near Primrose School, on land of J. L. Goodrich, the Sharon coal has also been opened and worked in a small way. The structure of the bed seen at the mouth of an old mine is as follows:

		Ft.	In.
Sandstone, shaly, dark		4	--
Coal, bony	*Sharon*	--	3
Clay shale		--	1
Coal		--	5
Clay shale		--	2
Coal, bony		--	4
Clay shale		--	1
Coal		--	6
Clay shale		--	2
Coal		1	2
Clay shale.			

In the vicinity of Byer and Richland Furnace no trace of the Sharon coal was found, for the Logan sandstone rises close to the horizon of the Sciotoville clay.

Jackson Township.—In Jackson Township, although the Sharon coal is due on nearly all of the high hills and ridges in the township, coal of workable thickness is found only in a few localities. In a part of the area it is entirely wanting, while in other parts it is represented by black, carbonaceous shale or thin, bony coals. In Section 36 the Quakertown coal is well developed, but the Sharon bed, where seen, is made up of dark, carbonaceous shales. The following section taken at the mine of Wm. McKinniss shows the relation observed:

		Ft.	In.
Coal, good	*Quakertown*	3	6
Coal, bony		--	5
Covered		62	--
Sandstone		6	--
Shale, gray		2	--
Shale, dark, carbonaceous, *Sharon* coal horizon		1	--
Shale, siliceous, gray		1	--
Conglomerate, *Sharon*		80	--

There is a roll at this place in the conglomerate of about 25 feet, but the blossom of the coal was found at the highest part of this, the coal conforming to the irregularity of the surface of the conglomerate. On land of John Faulkner, in the same section, the rocks measured are as follows:

		Ft.	In.
Shale, and covered		30	--
Coal, good	*Quakertown*	2	7
Coal, bony		--	6
Clay, sandstone, and covered		80	--
Coal blossom, *Sharon*		--	6
Clay, light, siliceous		4	6
Conglomerate, *Sharon*		95	--

In Section 25, on land of G. F. Lucas, there is a small pocket of Sharon coal. The structure of the deposit is as follows:

		Ft.	In.
Sandstone, with ore nodules and pebbles		1	--
Disconformity		--	--
Coal	*Sharon*	--	11
Clay shale, dark, carbonaceous		--	6
Coal, somewhat bony		1	1

Near the head of the hollow the horizon is represented by black shales. The interval from these to the Quakertown coal on the ridge to the west is approximately as given below:

	Ft.	In.
Coal, *Quakertown*	3	--
Covered	90	--
Sandstones, with shale partings	10	--
Shale, sandy	15	--
Shale, dark, with thin coal bands, *Sharon* coal horizon	1	--
Clay, light, siliceous	1	--

In this locality also there is a disconformity below the coal. The Sharon coal was open on land of Reuben Meacham in Section 26. The following section gives the thickness reported:

		Ft.	In.
Coal, good	*Sharon*	--	10
Shale parting		--	10
Coal, bony		--	10
Covered		14	--
Conglomerate, *Sharon*, not measured.			

On land of Thomas Jones, in Section 34, the coal was opened at one time, but no measurements were obtained. There is a large area in Section 27 above this horizon, but at no place was the coal found in any thickness. The coal areas in sections 28, 29, 30, 31, 32, and 33 are confined to small tracts on the high ridges and knobs. No coal of any importance was found. The coal is present with variable thickness in a few localities on the main ridge in Section 21, west. It was worked in a small way for local use on land of James Bryan. The section obtained there is given below:

	Ft.	In.
Sandstone, loosely cemented, coarse-grained, with pebbles	20	--
Coal, *Sharon*, reported thickness	1	8
Covered	5	--
Conglomerate, *Sharon*, very thick, not measured.		

The coal is opened on land of Peter Lew, Sr., and the measurements obtained are given in the following section:

	Ft.	In.
Sandstone, coarse-grained, pebbly	20	--
Coal, *Sharon*, reported thickness	2	11
Covered	8	--
Conglomerate, *Sharon*, massive, not measured.		

The coal is wanting or confined to small areas on isolated knobs and ridges in sections 17, 18, 20, west, 19 and 20, east. In Section 21 the rocks exposed along the road that leads from Little Salt Creek to the hill east are as given below:

	Ft.	In.
Pottsville formation.		
Covered	16	--
Sandstone, soft	10	--
Covered	11	--
Sandstone, coarse-grained, with pockets of pebbles	14	--
Covered	3	--
Shale	6	--
Sandstone, coarse-grained, with pebbles, ferruginous	2	--
Shale	1	--
Coal blossom, *Sharon*	--	6
Clay, dark	2	--
Conglomerate, *Sharon*	58	--
Logan formation.		
Shales, sandstones, and covered	125	--

Coal was formerly mined for local use on land of Wilson Terry. The section obtained follows:

	Ft.	In.
Coal, *Sharon*, reported thickness	2	--
Covered	15	--
Conglomerate, *Sharon*, massive, not measured.		

The Sharon coal was not found in Section 16. On land of John Tennant, in Section 22, the structure of the coal, with its associated rocks, is given in the following section:

		Ft.	In.
Sandstone, with parts covered, that near the coal, coarse-grained and pebbly		70	--
Coal	*Sharon*	--	10
Clay		--	1½
Coal		1	9
Shale, black, carbonaceous		1	--
Conglomerate, *Sharon*		40	--

In Section 15, on the property of A. A. Cooper, the impure deposit of Sharon coal was on the outcrop 1 foot 2 inches in thickness. The coal which lay close to the underlying conglomerate had a few feet of shale and a heavy sandstone for the roof. The following section showing the rocks exposed along the road that leads from Davis Hollow to Pine Grove School, marks the position of the Sharon coal:

	Ft.	In.
Sandstone, soft, red-colored	15	--
Shale, and covered	5	--
Sandstone, coarse-grained	29	--
Covered	21	--
Clay, *Sharon* coal horizon	3	--
Covered	11	--
Sandstones and shales, *Logan*	60	--

The Sharon conglomerate is wanting here and the coal horizon lies close to the sandstones of the Logan. The deposit has been opened at a few places in Section 23. A heavy blossom of the coal was seen below a massive sandstone on land of C. D. Harper. In the central part of the section under a thick sandstone, on land of J. M. Ray, the coal was found as follows:

		Ft.	In.
Sandstone, coarse-grained, with fine pebbles		22	--
Shale		--	5
Coal	*Sharon*	--	9
Clay, shaly		--	3
Coal, somewhat bony		1	9
Clay, dark, siliceous		1	--
Covered		8	--
Conglomerate, *Sharon*		75	--

The coal from this place dips rapidly to the north and the partings vary greatly in thickness. Just north of the above, C. D. Harper reports that he found 2 feet 4 inches of coal when digging his well. In the eastern part of the section, on land of J. M. Ray, coal is mined for local use. The structure of the deposit shown near the outcrop is given by the following record taken:

		Ft.	In.
Shale, blue		1	--
Coal	*Sharon*	--	11
Clay, shaly		--	5
Coal		1	9
Clay, siliceous, dark, and covered		14	--
Conglomerate, *Sharon*		30	--

In Section 14, from surface exposures, the Sharon coal appears to be wanting in most places, and the conglomerate is also thin or wanting. The coal was not found in any considerable thickness in Section 24. Dark, carbonaceous shales, representing the horizon, were seen at a few places in Section 13. On land of Clinton Harper the following rocks were exposed:

Pottsville formation.	Ft.	In.
Sandstone, soft	30	--
Shale, and covered	9	--
Shales, dark, carbonaceous, *Sharon* coal horizon	1	--
Clay shales, dark	9	--

Logan formation.	Ft.	In.
Shales	13	--
Conglomerate, fine-grained	1	4
Shales and sandstones	17	--
Covered	16	--
Shales and sandstones	30	--
Conglomerate, fine-grained	1	5
Sandstone	5	--

At another place, nearby, the section taken shows the following:

	Ft.	In.
Sandstone, soft	30	--
Conglomerate, very pebbly	4	--
Sandstone, soft	3	--
Covered	5	--
Shales, dark, carbonaceous, *Sharon* coal horizon	1	--

In sections 1 and 12 both the Sharon coal and conglomerate are seldom present. The horizon of the Sciotoville clay lies close to the Logan sandstones below. Along the road that leads from Ray to the ridge in the northern part of Section 12, several members or their equivalents are represented. The section taken there follows:

Pottsville formation.		Ft.	In.
Sandstone, highly cross-bedded, coarse-grained, with fine pebbles, red-colored. Same as seen at Richland Furnace, and over a wide area south		48	--
Covered		4	--
Coal blossom, *Anthony*		--	6
Clay, part plastic and part flinty, *Sciotoville* seen on outcrop		1	6
Sandstone, and covered		4	--
Shales, part sandy		7	--
Covered		9	--
Shale		4	--
Ore, *Sharon*		--	4
Shale		3	8
Shale, dark, carbonaceous, *Sharon* coal horizon		4	--
Clay and clay-bond sandstone, light		2	--
Sandstone, coarse-grained	*Sharon* conglomerate, equivalent	3	--
Sandstones and sandy shales		15	--
Conglomerate, pebbly with flint, brecciated, *Harrison* ore horizon		2	--
Logan formation.			
Sandstone		3	--
Conglomerate, fine-grained, of *Allensville*		2	--
Shales and sandstones		140	--

The Sharon coal was not found in sections 3, 4, 9, and 10. In fact, both coal and conglomerate are largely wanting. In Section 8 about 20 feet of conglomerate was exposed on the high ridge in the southwestern part, but no coal was seen above it. Along the main ridge in Section 5 from 30 to 50 feet of conglomerate were found, but the coal, at least in any considerable thickness, is wanting. The Sharon coal was found at no place in section 6 or 7.

The position of the Sharon coal is thus seen to be close above the Sharon conglomerate. It is laid down in irregular beds, which in a general way, conform to the uneven surface of the underlying conglomerate. This is especially noticeable north and west of Jackson where the coal follows the abrupt dip of the conglomerate which amounts to from 15 to 25 or more feet. In the southern part of the county the bed is either wanting or occasionally represented only by thin coals or bony shales. This condition appears to be due to parts of the Sharon conglomerate existing at that time as a land mass from which the pebbles in strata above the horizon of the coal were derived, and to parts of the submerged region being under conditions unfavorable for the formation or preservation of thick coal deposits, but conducive to the deposition of bony shales with occasional thin bands of coal and of peculiar dark-colored clay. The deposit is of workable thickness only in local areas, which are confined principally to Lick, Liberty, southern Jackson, and Coal townships. The Sharon coal is normally from 30 to 50 feet below the Sciotoville clay, while the Quakertown coal is from 25 to 40 feet above this bed. Thus the two coal deposits are separated by an average interval of from 70 to 90 feet, which is made up largely of sandstones and shales, with the well-marked Sciotoville clay intervening. Consequently they cannot be one and the same deposit as claimed by some.

Economic Value

The Sharon coal, which is dry-burning and low in sulphur, was discovered during the active period of the charcoal iron industry; hence it was immediately used for the smelting of iron, and thus has been of great value in maintaining this industry, especially in the Jackson region where large quantities are still used by the three blast furnaces now in operation. This bed also supplies a part of the fuel used locally for steaming and domestic purposes. The amount shipped at present to outside markets is small, as only a few mines are operated for this purpose.

It is a hard, bright, lumpy coal, with a more or less laminated structure, due mainly to very thin shaly partings. The sulphur averages low, seldom exceeding one per cent. It is a dry-burning, short-flamed coal with good heating value. The ash, usually white and non-clinkering, varies in amount from a few per cent to a high percentage, or, in fact, to the point where the material should not be classed as a coal, but as a carbonaceous shale. The moisture in the coal is high, which materially decreases its heating value. In the better grades of this coal the fixed carbon is high, exceeding that of the other main coals of the state, while the volatile matter is thus proportionately low.

The coal breaks down on weathering by parting along the bedding planes, and consequently is not well suited for long storage. The shipping qualities are good when freshly mined. All things considered it is as good as the other coals of the state. In Jackson County the Sharon coal has its maximum thickness and quality in the territory under Jackson, which at present is almost worked out. The quality of the Sharon coal is very good, as shown by the analyses given below:

[1]Two samples of the coal have been analyzed by Professor Wormley. No. 1 was taken from the Fulton shaft and No. 2 from the Star shaft.

	No. 1.	No. 2.
Specific gravity	1.282	1.267
Combined water	7.75	7.50
Ash	2.03	4.10
Volatile matter	31.27	30.90
Fixed carbon	58.95	57.50
Total	100.00	100.00
Sulphur	0.53	0.74
Cubic feet permanent gas per pound	----	2.51
Sulphur remaining in coke	----	0.22
Percentage of sulphur in coke	----	0.34
Percentage of iron in coal	----	0.102

The coal from the mine of Charles Booth, just west of the corporation line, is of excellent quality, and is a fair representative of that taken originally from the basin directly under Jackson. It is used for steaming coal at the Jackson Light Plant and for local domestic purposes.

Mr. J. F. Morgan, secretary of the Jackson Iron & Steel Company, reports as follows concerning their mine and the quality of the Sharon coal:

> This coal is reached by a shaft about 50 feet deep. The equipment consists of a tip house, hoist engine, screens, boilers, pumps and cars for mule haulage. Circulation of air in the mine is produced by fans. The double entry system of mining is used while the coal is mined by pick exclusively. The bed, known as the No. 1, varies in thickness from 2½ to 4 feet. As a general thing the thinner the deposit the better the quality of the coal. The amount mined per year is about 24,000 tons, providing the furnace is in operation, as it is used exclusively for furnace purposes. The quality of the coal is excellent for smelting purposes, *owing* to its low sulphur content. The comparatively high ash is not detrimental for furnace work, as high silicon iron is made. The analyses given below show the range and average composition of the coal:

Volatile matter	35.12	32.73	31.34
Fixed carbon	48.80	53.48	50.65
Ash	8.07	6.32	8.60
Sulphur	.41	.447	.449
Phosphorus	.057	.053	.060
Silica	3.76	2.87	3.92

Just north of the shaft mine of the Jackson Iron & Steel Company,

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[1] Geol. Surv. of Ohio, Report of 1870, p. 149.

James B. Paine has lately (1913) opened a slope to the Sharon coal. Most of the output is used locally, but some is loaded for railroad shipment as the mine is located on the Detroit, Toledo & Ironton Railway. Concerning the mine Mr. Paine reports as follows:

> The mine is equipped with boiler, engine, and drum for hoisting the coal, and pumps for removing the water. The maximum thickness of the bed is 4 feet 2 inches and the minimum about 3 feet, with an average of close to 3 feet 6 inches. There is a layer of bone coal in the lower part of the stratum. The roof is a thick shale with sandstone above. The bed is rather irregular with a big dip just south of the opening. The analysis of the coal is as follows:

Moisture	9.05
Volatile matter	35.50
Fixed carbon	48.98
Ash	6.47
Total	100.00
Sulphur	.431

> The number of men employed depends somewhat on the season of the year, but the average is about five. The coal is well liked for domestic and steaming purposes.

Mr. J. E. Jones, general manager of the Globe Iron Company, reports as follows:

> The coal we are mining is the No. 1 bed. Our system of mining is by double entry and by cutting with electrical machines. The main haul is done by electric locomotive, but the gathering is done by mule power. We produce on an average 200 tons lump coal per day. As our blast furnace was only in blast three months the amount mined last year was only 10,480 tons. All the lump coal mined by this company is used in our blast furnace for smelting purposes, and the fine coal is used for boiler purposes, both at the mines and at our blast furnace. On account of the coal being open burning, non-cementing, and low in sulphur, we find it valuable for blast furnace purposes. In fact, it is the only coal that we know of in this state that can be used as such. The average analysis is approximately as follows:

Fixed carbon	49.50 per cent.
Volatile matter	33.50 per cent.
Ash	9.00 per cent.
Moisture	7.50 per cent.

In Jackson County the known area of the Sharon or No. 1 coal field, in which the deposit is of workable thickness or in which it may be present in workable thickness, approximates closely 25 square miles. Owing to wants, thin places, shaly conditions, and weathered outcrop, not to exceed 50 per cent of this is workable. Of this area that near Jackson and along the line of the Detroit, Toledo & Ironton Railway west of Jackson is rapidly nearing exhaustion. There are some very good small areas yet in Liberty Township, which will supply the future local demands for many years. Coal for railroad shipment is mined by the Sun Coal Mining Company, Wood Coal Company, and Armstrong Coal Company.

SHARON IRON ORE

The horizon of the Sharon iron ore is close above that of the Sharon coal. In some cases the ore lies directly on the coal, while at other places it may be 15 or 20 feet above. The member is very uncertain and is found only in a few localities in Jackson County. As a usual thing the ore is fossiliferous, which character is thus of some aid in the correlation of the members near the base of the Pottsville. In a local area, west of Jackson, a black band ore is found on this horizon. In Section 28, Liberty Township, at the Decatur No. 1 mine, on the N. B. Wood property, the section obtained shows this ore and the relation to the coal below. The record follows:

	Ft.	In.
Sandstone, with small kidney ore nodules	1	--
Sandstone, coarse-grained, and with pebbles	2	4
Ore, nodular, *Sharon*, irregular, present in places only	--	6
Shale, blue	2	6
Coal, good } *Sharon*	2	11
Coal, bony } *Sharon*	4	--
Clay	1	--
Conglomerate, *Sharon*, not measured.		

Along the road north of the home of J. W. Bower, in Section 3, Liberty Township, the following rocks were exposed:

	Ft.	In.
Ore, *Sharon*, with pebbles	--	6
Sandstone	5	--
Sandstone, with pebbles	2	--
Covered	1	--
Coal blossom and clay, *Sharon*	1	--
Conglomerate, *Sharon*	55	--
Sandstone, *Logan*	85	--

At the old Glen Nell mine, in Section 20, Washington Township, the Sharon ore lies close to the Sharon coal, as shown by the following section:

	Ft.	In.
Sandstone, coarse-grained, interbedded	12	--
Ore, *Sharon*, irregularly bedded, with pebbles in places, fossiliferous	--	7
Shale, dark, carbonaceous	--	4
Coal, *Sharon*	3	1

In some parts of the mine the ore is reported to lie on the coal while in other parts it is a foot or two above. It is also reported very uncertain. The relation of the ore to the coal below is shown in a section taken on land of J. L. Goodrich in Section 16, Washington Township. The section is given below:

	Ft.	In.
Shale, sandy	6	--
Ore, *Sharon*, with some pebbles, fossiliferous	--	6
Shaly sandstones and sandy shales	14	6
Coal, *Sharon*, part bony	2	--

The Sharon ore was found along the road that leads from Ray to the ridge in the northern part of Section 12, Jackson Township. The ore and its relation to other members is shown in the following section:

		Ft.	In.
Pottsville formation.			
Sandstone, highly cross-bedded, coarse-grained, with fine pebbles, red colored. Same as seen at Richland Furnace		48	--
Covered		4	--
Coal blossom, *Anthony*		--	6
Clay, part plastic and part flinty, *Sciotoville*, seen on outcrop		1	6
Sandstone and covered		4	--
Shale, part sandy		7	--
Covered		9	--
Shale		4	--
Ore, *Sharon*		--	4
Shale		3	8
Shale, dark, carbonaceous, *Sharon* coal horizon		4	--
Clay and clay-bond sandstone, light		2	--
Sandstone, coarse-grained	*Sharon* conglomerate, equivalent	3	--
Sandstone and sandy shales		15	--
Conglomerate, pebbly with flint, brecciated, *Harrison* ore horizon		2	--
Logan formation.			
Sandstone		3	--
Conglomerate, fine-grained, *Allensville*		2	--
Shales and sandstones		140	--

The Sharon iron ore has been worked at only a few places in Jackson County. The old charcoal furnaces obtained small amounts of ore from this horizon, and the present furnaces have used some obtained as a secondary product from coal mines. The ore is low in iron, usually siliceous, and variable in composition. A partial analysis of the black band ore from the mines of the Star Furnace Company was furnished by Mr. H. L. Clay, and is as follows:

Iron	31.00
Silica	6.20
Alumina	4.28
Phosphorus	.152
Manganese	.65
Lime	.95
Magnesia	1.08

The supply of these ores is limited, but small amounts may be obtained in the future in restricted areas as a secondary product from mining the Sharon coal.

SHALE AND SANDSTONE ABOVE THE SHARON COAL

Above the Sharon coal is a shale deposit, rich in fossils of coal formation plants, which evidently belongs to the same general time cycle as the coal below. The line of contact with the materials above is usually well marked, as this is either a massive sandstone, which in places is only a few feet above the coal, or a siliceous clay carrying a thin coal stain. The thickness of the deposit varies from 4 to as much as 30 feet, but the usual range is from 10 to 20 feet. It has a gray color due partially to organic matter, and a coarse texture compared to that of the ordinary shale. On exposure to the weather, it breaks down to a mud with medium plasticity. It is a siliceous shale, low in fluxes and from general appearance well adapted for the manufacture of ceramic products. No tests were made by the Survey, but the nature of the material suggests its fitness for the manufacture of paving brick or sewer pipe. No use has been made of this shale in Jackson County.

The massive sandstone, containing more or less quartz pebbles, found above the horizon of the Sharon coal in Pike County, and described in that report, is also prominently developed in Jackson County. In many localities the sandstone lies directly on the coal, i. e., it forms the roof of the bed, while in other localities the sandstone and coal are separated by shales, the thickness of which is quite variable, ranging from 1 foot to 20 or 30 feet. There is no well defined unconformity at the base of this sandstone. It does not gradate into shales in this region at least, but is often broken into layers with shales intervening. In some localities the sandstone is wanting also, and in a general way the shales thicken in passing southeastward. The association and general structure of the deposits rather suggest that both materials were brought in by the same general currents, but that the shales were laid down in protected or quiet spots. Shifting of the line of current action would give the interbedding noticed in some localities. The large quartz pebbles may have been derived entirely or in part from land areas of Sharon conglomerate, for they are very similar to the pebbles in this member. There are other sandstones above this that are coarse-grained, and contain some fine pebbles, which would thus indicate a common origin. This sandstone may correlate with that of the Lower Connoquenessing of Pennsylvania, since it has much the same general character and position. It has no special economic value, but has been worked for sand at a few places.

SCIOTOVILLE CLAY AND ANTHONY COAL

The Sciotoville clay and Anthony coal are found above drainage in the western part of Jackson County, in a belt extending northward from the Scioto-Jackson line in Hamilton Township to the Jackson-Vinton line in Jackson and Washington townships. Neither the clay nor the coal is persistent, as many wants are found in the belt. Only small areas of high-grade flint clay are found on the Sciotoville horizon, and in a few places only is the Anthony coal of sufficient thickness or quality to be worthy of consideration.

Stratigraphy and Area

The Anthony coal is found directly associated with the Sciotoville clay. During the deposition of these members many local variations of level, or changes of conditions, took place, as will be noticed by an examination of the sections recorded. Thus, on account of the variable nature of the interval, it is hard to state definitely the position of the coal with reference to any particular bed on the clay horizon, as these change rapidly, and as the interval is often made up of a series of clays, very similar in appearance, separated by the coals or carbonaceous shales. In some cases the heaviest coal deposit lies directly on the flint clay; then again, it may be separated from this by several feet of plastic clay, or by a series of plastic clays, with thin coals or black shales intervening. In this bulletin the coal stratum of maximum thickness, found on this general horizon, has been designated the Anthony coal, although that found in one locality may not have been laid down at exactly the same time as that found in another, but both were deposited during the same general swamp conditions.

The Anthony coal was named by Dr. Orton after examination of a coal bed on the land of Samuel Anthony, Section 7, Coal Township.

Hamilton Township.—The Sciotoville clay and Anthony coal extend across Hamilton Township, but the areas above drainage, in which the deposits have good thickness and quality, are somewhat local. High-grade flint clay is less common than the plastic clay. No information in regard to the extent of the beds below cover was obtained.

In Section 28, on the land of R. A. Dever, both the Anthony coal and underlying Sciotoville clay are found with good thickness. An entry has been driven into the hill and some coal mined. The mouth of the mine is just across the line in Scioto County, where the strata exposed are as follows·

	Ft.	In.
Shale	6	--
Sandstone	--	8
Ore, sandy, with pebbles, *Guinea Fowl*	--	4
Shales, dark	6	--
Coal, good, *Anthony*	3	--
Clay, sandy, *Sciotoville*	4	--
Covered	20	--
Sandstones and shales, *Logan*	15	--

Just across the hollow a good exposure of the rocks shows the following relations:

		Ft.	In.
Shales.			
Coal blossom, *Anthony*		--	6
Clay, dark flint	*Sciotoville*	3	--
Clay, light, sandy, plastic		5	6

The coal has been opened at this place, but is reported only about 1 foot in thickness. The flint clay is good on this side of the hollow, where the coal is thin, but on the other side, where the coal is thick it is absent, or at least not exposed. On the land of F. M. Dever in the eastern part of Section 28, the deposit has been opened, and some flint clay, which is of good quality, mined for brick making. No section was obtained. In Section 27, at the Valley School, the Sciotoville clay has been mined on the land of Delmer Dever, while the Bear Run coal is worked on the hill north of this on the land of S. B. Gilliland. The clay mine has fallen, so no good exposure was obtained. The clay mined was a hard flint of good quality. A section taken here is as follows:

		Ft.	In.
Shales, lower part fossiliferous		10	--
Coal, *Bear Run*		1	4
Covered, barometer measurement		78	--
Clay, flint, reported thickness	*Sciotoville*	3 to 7	--
Clay, "pink eye"		5	--

The Sciotoville clay and Anthony coal go under cover near the eastern line of Section 27. The Sciotoville clay is exposed in Section 21 near F. M. Dever's house, but no section was taken. It is a flint clay of good quality. In Section 14, on the land of Philip Meldick, the rocks exposed just south of the bridge that crosses Little Scioto River are as follows:

		Ft.	In.
Shales with *Guinea Fowl* ore		5	--
Coal blossom, *Anthony*		--	6
Clay, plastic, dark blue, *Sciotoville*		4	--
Shales and covered		18	4
Ore, *Harrison*		--	8
Sandstones, thin-bedded and shaly	*Logan*	11	4
Sandstone, ferruginous		--	8
Sandstone, light blue		3	--

A composite section taken in Section 11, near the McCoy Church on the land of Edward Gahm, is as follows:

	Ft.	In.
Ore, fossiliferous, probably *Lower Mercer* limestone changed to ore	--	6½
Shales and covered	35	--
Shale	5	--
Sandstone, fissile	--	8
Clay shale, light	2	8
Limestone, bastard	1	--
Shales, *Lower Mercer* coal horizon near top of shales	35	--
Covered	10	--
Shale	4	--
Coal, *Vandusen*	1	--
Covered	3	--
Sandstone, massive	25	--
Covered	32	--
Sandstone	10	--
Covered. *Guinea Fowl* ore in interval, not seen in place	8	6
Shale, dark blue	2	--
Shale, light blue	2	6

	Ft.	In.
Coal, *Anthony*	--	11
Clay, dark, sandy, *Sciotoville*	3	6
Clay shales, blue, sandy	3	--
Sandstones, *Logan*	5	6

In the eastern part of Section 11, on the land of Vinton McCoy the Anthony coal has been mined in the bed of the stream just east of his house, and also in the bed of the small stream north of the house. The section east of the house is as follows:

		Ft.	In.
Ore, sandy		--	8
Shales, dark		9	--
Shales, gray		3	--
Covered		4	--
Sandstone, dense, ganister		2	--
Covered and sandstone		30	--
Coal, good	*Anthony*, reported thickness	--	7
Shale, carbonaceous		--	5
Coal, good		2	--

North of the house the section is as given below. The upper part of this section is on Wm. H. Gahm's land.

	Ft.	In.
Coal, *Lower Mercer*, reported thickness	2	6
Sandstone, massive	21	--
Shales	9	--
Coal, *Vandusen*	1	--
Clay and shales	5	--
Sandstone with parts covered	40	--
Sandstone, shaly, blue, with shales intervening	20	--
Shales, blue	10	--
Coal, *Anthony*, reported thickness	1	2

This coal comes to the surface again farther up the creek on the land of J. W. Davis, in Section 12, where it has been benched in the bed of the stream. A measurement made on the lands of J. W. Davis and Hugh Gilliland is as follows:

	Ft.	In.
Shales	4	--
Coal, *Vandusen*	1	--
Sandstone, flaggy, with shale partings	53	--
Coal blossom, *Quakertown*	1	--
Sandstone	10	--
Sandstone, flaggy	5	--
Covered	10	--
Coal, *Anthony*, reported thickness	1	6

In Section 16, on land of Philip Flaker, on Bucklick Creek, a series of plastic clays with intervening carbonaceous shales and thin coals is present, a section of which is given below:

	Ft.	In.
Coal blossom, *Vandusen*	--	6
Clay, sandy	1	6
Shale	12	--

		Ft.	In.
Ore, kidney	*Jackson Sand Block* horizon	--	3
Shales		5	9
Ore, kidney, three layers		--	10
Shale		--	8
Ore, kidney		--	4
Shale		--	2
Ore, kidney		--	4
Shale		11	8
Sandstone, massive		8	--
Covered		3	--
Shale, sandy		14	6
Bone, shale, dark		--	6
Shale, sandy		1	--
Sandstone, shaly		3	--
Clay, light, sandy		2	--
Shale, dark blue		2	--
Shale, sandy		5	6
Ore, kidney, irregular		--	6
Shale, blue, sandy		3	--
Shale		15	--
Ore, kidney, *Guinea Fowl*		--	5
Shale		--	7
Clay, plastic, dark	*Sciotoville*	3	6
Clay shale, dark, with thin coal bands		1	--
Clay, blue, plastic, good quality		5	6
Clay, sandy		1	--
Ore, sandy		--	6
Clay, dark, plastic, good		2	6
Clay, irony, "pink eye"		3	--
Sandstone, dense, fine-grained		1	--
Clay, dark, plastic, good		6	--
Shale, dark, with thin coal bands		1	--
Clay, dark, plastic, good		2	--
Clay, dark, plastic, with small ore nodules		1	6
Clay, dark, plastic, sandy		2	--
Sandstone, shaly		5	6
Sandstone, *Sharon*, ferruginous, with pebbles		1	--

The clay or coal on this horizon is found in several places farther up Bucklick Creek, but neither is of much value. In Section 4, near the cross-roads, on land of George W. Karn, the following section was taken:

		Ft.	In.
Sandstone		1	--
Coal, dense	*Anthony*	--	8
Shales, dark		1	3
Coal, dense		1	2
Clay, dark, sandy		2	--
Clay shales		5	--
Ore, siliceous, pebbly, *Guinea Fowl*		1	6
Shales		1	3
Coal stain		--	1
Clay, flint, siliceous, light, plant marked	*Sciotoville*	4	6
Clay, semi-flint, siliceous, light		3	--
Clay, sandy, with ore nodules		1	--

Scioto Township.—In Scioto Township the Sciotoville clay is locally represented by deposits of high-grade flint clay, but the Anthony coal is seldom more than beds of highly carbonaceous shales. The members are found in the southeastern part, near drainage level, along the headwaters of Sugarcamp Creek, and in the western part near the summits of the hills east of the preglacial California Valley. In the southern part of Section 32, on land of Robert Wooten, flint clay of excellent quality is exposed. The exact thickness could not be determined, so the following section may represent only a part of the deposit:

	Ft.	In.
Clay, flint, excellent. *Sciotoville*	4	--
Covered	66	--
Shale	3	--
Coal blossom, *Sharon*	--	6
Clay, plastic	2	--

In Pigeonroost Hollow, on the land of William Engle, in Section 34, a record of the strata exposed on this horizon is as follows:

		Ft.	In.
Clay shales, weathered, pinkish. probably "pink eye"	*Sciotoville*	7	6
Clay, dark, plastic		1	6
Clay, dark, siliceous		2	--
Clay, light, siliceous		--	6
Covered		4	--
Coal		--	2
Shales, very carbonaceous, tough, fissile		1	6
Sandstone, with ore nodules		--	6
Conglomerate, *Sharon*		10	--

In the southeast corner of Section 28, on land of Adam A. Gahm, the horizon is represented by carbonaceous shales and plastic clay. The section taken follows:

	Ft.	In.
Ore, composed of sandstone layers, brecciated and nodular ore masses very irregular in thickness	3	--
Disconformity.		
Shale, tough, dark, carbonaceous, *Anthony* coal horizon	4	--
Clay, *Sciotoville*, bluish, soft	1	6
Covered	8	--
Conglomerate, *Sharon*	3	--

In the northern part of the same section, on land of Harvey Gahm, the flint clay is exposed in the bed of a small stream. Mr. Gahm, who dug through the stratum, reports it to be as follows:

	Ft.	In.
Shales, with coal, *Anthony*	1	--
Clay, flint, good quality, *Sciotoville*, reported thickness	3	--

In Section 26, near Grahamsville, the clays, coals, and carbonaceous shales are exposed in the bed of the creek on lands of W. H.

and Eliza J. Pierce. East of this, on the land of Martin Wastier, the Jackson Sand Block ore has been worked. The section here, as near as could be obtained, is as given below:

		Ft.	In.
Ore, kidney		--	4
Shales, part sandy		27	--
Ore, kidney		--	3
Shales, sandy		7	9
Covered		6	--
Shales		2	--
Coal, *Vandusen*		--	6
Sandstone, argillaceous		3	--
Sandstone, light		3	6
Ore, sandy	*Jackson Sand Block*	1	2
Shales		1	5
Ore, sandy		--	6
Sandstones, flaggy		6	--
Shales		26	--
Coal blossom, *Bear Run*		--	4
Shales		6	--
Sandstone, plant marked, ferruginous		1	--
Shales		16	--
Sandstones, flaggy, with shales		13	--
Coal and bone shale		2	--
Clay, light, sandy		1	6
Shales		1	--
Thin sandstones and shales		2	--
Sandstone		--	7
Shales, blue		--	5
Coal, *Anthony*		--	1
Clay, light, plastic, with "pink eye"	*Sciotoville*	4	4
Clay, dark, shaly		3	8
Clay and covered		5	--
Coal		--	1
Clay, flint, sandy		1	6
Covered		20	--
Conglomerate, *Sharon*		10	--

These members are also present just west of Petersburg, but are of no importance. Near the head of Sugarcamp Creek, south of the Fairview School, the upper part of this horizon was noted in the bed of the stream on land of Fred Yingler. A section taken from here to the school is as follows:

	Ft.	In.
Ore, *Sand Block*, *Upper Mercer*, fossiliferous	--	7
Covered	43	--
Ore, *Lower Mercer*	--	6
Covered	6	--
Shales, sandy	8	--
Shaly sandstones and sandy shales	11	--
Sandstone, light	2	--
Shales, part sandy	12	--
Shales and covered	10	--

		Ft.	In.
Shales		15	--
Shales and covered		16	--
Limestone, nodular, bastard		1	--
Shales		13	--
Shale, dark		--	8
Coal blossom, *Vandusen*		--	8
Shales, carbonaceous, dark		1	--
Clay, dark, sandy		1	--
Shales		9	8
Coal blossom, *Bear Run*		--	8
Shales and sandstones		31	4
Covered, this interval may be more as there is a local dip to strata		10	--
Sandstones, flaggy		2	--
Ore, *Guinea Fowl*		--	4
Coal		--	3
Clay shales		1	10
Clay, dark		2	6
Shales, dark, tough, carbonaceous		1	4
Coal, *Anthony*		--	5
Clay, sandy	*Sciotoville* clay horizon	--	6
Sandstones, thin bedded, plant marked		1	10
Clay, sandy, dark		--	4
Sandstone, light		--	3

In sections 9 and 16, on the isolated knob west of Wm. B. Pratt's house, high-grade flint clay occurs at this horizon on lands of Mr. Pratt and Fred Flaker. The clay bed was not exposed. A section is given below:

	Ft.	In.
Clay, flint, good, *Sciotoville*, reported thickness	2	--
Sandstone	2	--
Shales and covered	35	--
Coal blossom, *Sharon*, reported here, seen on next hill 3 feet thick.		
Covered	18	--
Conglomerate, *Sharon*	24	--

Along the road, in the southwestern part of Section 2, the following strata were seen:

		Ft.	In.
Sandstones, thin to medium bedded, ferruginous	*Jackson Sand Block* ore	7	--
Covered		5	--
Sandstone, ferruginous		1	--
Shales		7	--
Sandy shales and thin flaggy sandstones		12	--
Sandstone, with ore nodules		2	--
Shales, sandy		3	--
Covered		4	--
Sandy shales and thin sandstones		18	--
Covered		16	--
Clay, plastic, *Sciotoville*		3	--
Shales, sandy		2	--
Covered		10	4
Sandstone, with ore nodules		--	8

	Ft.	In.
Sandstone, shaly	5	--
Shales	10	--
Conglomerate, *Sharon*	6	--

On the Sawyer property, in Section 7, the clay is exposed, and below it the Sharon coal is being worked. A section here is as follows:

	Ft.	In.
Ore, with pebbles, *Guinea Fowl*	--	6
Covered	5	--
Coal stain, *Anthony*	--	2
Clay, plastic on outcrop, upper part siliceous, "pink eye" at bottom, *Sciotoville*	13	8
Sandstone, massive	11	--
Shales	13	6
Coal, *Sharon*	2	6
Covered	14	--
Conglomerate, *Sharon*	16	--

In the northwest corner of Section 6, on the Robert Lamb property, high-grade flint clay occurs at this horizon. Measurements made on this farm follow:

	Ft.	In.
Clay, flint and semi-flint, *Sciotoville*	6	--
Covered	32	--
Sandstone, massive	5	--
Coal, *Sharon*	2	4
Covered	10	8
Sandstone, massive } *Sharon*	10	--
Conglomerate	16	--
Covered	10	--
Sandstone, *Logan.*		

In Section 6, Scioto Township, on land of Joseph West, high-grade flint clay was exposed at the surface on the knob near Mountain Ridge Cemetery. Below this the Sharon coal has been opened, but here it is very bony, while to the west, on the Lamb property, it is of good quality. The coal lies on the Sharon conglomerate, which to the west or south is found very massive and pebbly. The section measured follows:

	Ft.	In.
Clay, both flint and plastic, exposed on outcrop, *Sciotoville*	5	--
Covered	45	--
Coal blossom, *Sharon*	4	--
Conglomerate, *Sharon*	5	--

South of this, in Section 5, on the land of J. T. Rhea, excellent quality of flint clay was seen on the outcrop, but its relation to other members could not be determined, as the rocks were largely covered. The same quality of clay was also observed on land of Margaret Moles in Section 8.

Liberty Township.—The Sciotoville clay and the Anthony coal are poorly represented in Liberty Township. Good flint clay was found only in Section 14, but plastic clay was noted at several places in the eastern part of the area. A few sections of the rocks will be given in order to show the general relations of these beds to other well recognized strata. On land of Martha Lake, Section 23, Liberty Township, the following rocks were exposed along the roadside:

	Ft.	In.
Ore, very siliceous, *Guinea Fowl*	--	9
Shale	5	6
Ore, kidney	--	2
Shale	--	6
Ore, kidney	--	1
Clay, part flinty, *Sciotoville*	5	6
Covered	6	--
Sandstone, massive, with a few pebbles	14	--
Disconformity. Horizon of *Sharon* coal.		
Conglomerate, *Sharon*	19	--

In Section 14, on the property of Simon David, a flint clay of good quality was exposed on the outcrop. From general appearance it is the Sciotoville clay. The section follows:

	Ft.	In.
Clay, flint, good, *Sciotoville*	3	--
Covered	12	--
Conglomerate, *Sharon*	60	--

Lick Township.—On a branch of Buffalo Skull Creek, near the crossing of the Jackson and Chillicothe road, a section was taken on the land of Charles Walden, Section 18, Lick Township. It is as follows[1]:

	Ft.	In.
Coal, "Anthony's Seam," not exposed for measurement.		
Under clay Conglomeratic sandstone with iron ore Coarse sandstone Dark shales	36	--
Coal, highly laminated and resembling "Jackson Shaft coal," not fully exposed.		
Sand-rock.		

Coal Township.—In Coal Township the Sciotoville clay and Anthony coal are best represented in the southwestern part in sections 6 and 7. The horizon is above drainage along the valley of Pigeon Creek in the northwestern part also, but the members are seldom present. In Section 7, on land of Arthur Howe, the Sciotoville clay, part flint of good quality, the Quakertown coal, and black shale on the Sharon coal horizon are found. The section measured here is as given below:

	Ft.	In.
Coal, *Quakertown*, reported thickness	1	3
Covered	31	--
Sandy shale, with thin sandstone layers	13	--

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[1] Geol. Surv. of Ohio, Rept. for 1870, p. 141.

	Ft.	In.
Clay, flint, good quality, *Sciotoville*	5	--
Covered	9	--
Sandstone, massive	11	--
Shale	3	--
Covered black shales opened here, *Sharon* coal horizon	8	--
Clay, sandy, light	5	--
Covered	37	--
Conglomerate, *Sharon*	25	--

Just east of this, on Louis Mapes' land, the flint clay occurs again. The strata seen are given below:

	Ft.	In.
Coal, *Quakertown*, reported thickness	3	--
Shales and covered	38	--
Clay, flint, good quality, *Sciotoville*, reported thickness	3	--
Covered	21	--
Sandstone with pebbles in places	27	--
Coal blossom, *Sharon*	1	--

On the Charles McKinniss land, in Section 6, the clay is exposed by the side of the road near the foot of the hill. The section exposed is as follows:

	Ft.	In.
Coal, *Quakertown*	2	6
Covered	26	--
Sandstone	2	6
Shales, gray	9	--
Coal blossom, *Anthony*	--	6
Covered	3	--
Coal	--	2
Clay, flint, good quality, *Sciotoville*	3	6

The coal above the clay here was opened at one time. The section taken by Dr. Orton is given below:[1]

Blossom of coal.		Ft.	In.
Not seen		8	--
Clay shales		10	--
Coal	[*Anthony*]	3	--
Clay, slate, reported		--	4
Coal, slaty, reported		1	2
Not seen		9	--
Fire-clay, very hard and good, [*Sciotoville*]		3	--

Terms in brackets were supplied by the writer.

Jackson Township.—The only locality in Jackson Township where the Sciotoville clay and the Anthony coal show normal development is along Pigeon Creek, in the vicinity of the village of Ray. In local areas here the clay is of good thickness and quality, while the coal has sufficient volume to be mined for local use. Along the road that leads from Ray to the ridge, in the northern part of Section 12, Jackson Township, the following rocks were exposed:

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[1] Geol. Surv. of Ohio, Rep. for 1870, p. 142.

	Ft.	In.
Pottsville formation.		
Sandstone, highly cross-bedded, coarse-grained, conglomeratic, red colored. Same as seen at Richland Furnace and over a wide area south	48	--
Covered	4	--
Coal blossom, *Anthony*	--	6
Clay, part plastic and part flinty, *Sciotoville*, seen on outcrop	1	6
Sandstone and covered	4	--
Shales, part sandy	7	--
Covered	9	--
Shales	4	--
Ore, *Sharon*	--	4
Shales	3	8
Shales, dark, carbonaceous, *Sharon* coal horizon	4	--
Clay and clay-bond sandstone	2	--
Sandstone, coarse-grained	3	--
Sandstones and sandy shales	15	--
Conglomerate, pebbly with *Sharon* conglomerate equivalent; flint, brecciated *Harrison* ore horizon	2	--
Logan formation.		
Sandstone	3	--
Conglomerate, fine-grained, of *Allensville*	2	--
Shales and sandstones	140	--

There is a coarse-grained highly cross-bedded sandstone, much resembling the upper sandstone in this section above the Sciotoville clay, in the clay region of Scioto County. The brecciated flint from the Harrison ore thus marks the line of disconformity between the Pennsylvanian and Mississippian rocks. Just across the ridge from where the above section was taken the Anthony coal has been mined in a small way for local use. The section obtained on land of T. A. Harper, in Section 11, is as given below:

		Ft.	In.
Sandstone, coarse-grained, with shaly layers		10	--
Coal	*Anthony*, reported thickness	1	1
Clay		--	3
Coal		1	--

Mr. Harper reports that the overlying sandstone replaces the coal, and that the bed is not regular. North of this, in Section 2, on the land of Amos Linton, the rocks exposed were as follows:

		Ft.	In.
Irregular layers of sandstone with pebbles and clay		1	2
Plastic clay with sand layers, rather a mixture of sand and clay	*Sciotoville* horizon.	1	--
Clay, dark, sandy, somewhat flinty in nature		6	--
Covered		2	--
Ore		--	4

In Section 2, Jackson Township, on the land of A. Speakman, the Anthony coal has also been opened and worked in a small way. The coal was not seen when the region was visited, but it is reported to be 1 foot 8 inches in thickness. The section obtained is as follows:

		Ft.	In.
Shale		2	--
Ore, siliceous	*Guinea Fowl*	--	4
Shale		1	2
Ore		--	3
Sandstone		--	2
Shale		--	8
Clay shale		8	--
Covered		3	--
Coal, *Anthony*, reported thickness		1	8

In Section 1, north of Pigeon Creek, on land of the Chillicothe Brick & Coal Company, the Sciotoville clay has been mined for shipment. The clay is of good quality, but the bed was reported to be uncertain. In this region the Anthony coal, which thickens in places to as much as 1 foot 8 inches, has been mined for local use. The structure of the clay deposit reported is as follows:

		Ft.	In.
Coal, *Anthony*, reported thickness		1	4
Clay, flint, good	*Sciotoville*	4	--
Clay, light, plastic		7	--

The flint clay in this locality lies in pockets, which are quite local. About 100 feet west of the clay mine the structure of the deposit observed in an old opening is as follows:

		Ft.	In.
Sandstone, with finger coals. This sandstone in places dips down, cutting out both coal and clay below		2	--
Shale, black, carbonaceous	*Anthony*	--	4
Coal, bony, cannel nature		--	8
Shale, dark		5	--
Clay, shaly, *Sciotoville*		3	--

East of this, on land of William Doles, the coal is mined for local use. The section follows:

	Ft.	In.
Shale	5	--
Coal, *Anthony*, reported thickness	1	8
Clay, dark, siliceous, *Sciotoville*.		

The Sciotoville clay was formerly mined on the Richland Furnace land in Section 4, Richland Township, Vinton County. The record obtained here will also be given:

	Ft.	In.
Ore, *Lower Mercer*.		
Covered	45	--
Sandstone and covered	25	--
Shale and covered	25	--
Sandstone and covered	15	--

		Ft.	In.
Covered		16	--
Shale, light		12	--
Ore, irregular layers		--	4
Shale		1	10
Clay, flint, good	*Sciotoville*	4	--
Soft clay and covered		4	--
Clay, red, "pink eye"		6	--
Sandstone, clay-bond, light		2	--
Covered		22	--
Sandstone, coarse-grained, *Sharon* conglomerate equivalent		8	--
Shale, *Logan*		6	--

The Sciotoville clay was found at two places in Vinton County north of Richland Furnace and is thus shown to extend across Jackson County, entering from Scioto to the south and passing into Vinton to the north. It is not persistent, as in many places it is wanting, being replaced usually by heavy sandstones. The variability of the structure of the deposit is also pronounced. In some places it is made up of a number of strata of clays varying in quality and texture, while at other places it may be represented by a single stratum. In Jackson County only small areas of the hard flint clay, characteristic of the deposit in Scioto are found, but in these the clay is generally of excellent quality. The strata of plastic clay vary in thickness from place to place, and the clays vary in quality, from the impure, irony "pink eye" and siliceous types to the light pure grades.

The Anthony coal associated with the Sciotoville clay is thus found to be thin or shaly, except in a few small local areas where it reaches some thickness and a high state of purity. Coal on this horizon is as constant as the clay below. The irregularity in the structure of these members can be accounted for only by a succession of local changes in the swamp conditions during the period of deposition. A study of the recorded sections suggests that a mere shifting or a slight changing of conditions only is necessary for the deposition of clay in one case or coal in another.

Economic Value of Sciotoville Clay

The value of this clay for the manufacture of high-grade refractory ware has been treated in the report on Scioto County, where this deposit forms the basis of the long established and prosperous fire brick industry. The high-grade flint clay of this member in Jackson County is restricted to comparatively small isolated pockets, which should be thoroughly prospected by the drill before the establishment of brick works. Counting 60 per cent available in mining, one acre of clay where the deposit averages 3 feet in thickness will mine a little more than 6,000 tons. It takes 4 tons of clay to make 1,000 brick, so a plant with a daily capacity of 15,000, running 300 days per year, will require about 18,000 tons of clay, or the clay from 3 acres of land,

and for a 20 years' run the actual acreage of good clay 3 feet thick should be at least 60. From the exposures noted the most promising fields are in the southern part of Scioto Township and in the southwestern part of Coal.

The amount of plastic clay on this horizon greatly exceeds that of the flint, as the beds are usually much thicker and far more persistent, but for high-grade refractory ware the soft clays are inferior to the hard flints. These highly aluminous plastic clays may be utilized in the manufacture of a special grade of metallurgical ware, in which great density and resistance to the action of slags or gases, and in which only moderate refractoriness are required. The best of these plastic clays, often as low in fluxes as the flints, withstand safely a temperature of 3,000° F. before fusion, but vitrification sets in much earlier.

Buff and iron mottled building brick, very durable and attractive, are easily made from these plastic clays. When burned at moderate temperatures, the clay, on account of the high alumina with the small amount of iron oxides, goes to a bright golden buff, and when burned harder it changes to the brownish tint and then to the iron mottled shades. The "pink eye" clays, or those with the high iron content, under hard firing, give blacks, but when diluted with other clays they give the large black blotches on a lighter background which is quite pleasing to the eye. These clays, especially where part of the deposit is semi-flint, are well fitted for the manufacture of the highest grades of building brick. Under these conditions the working qualities are very good throughout the whole operation, and the ware is dried and burned safely with only a small loss.

The problem of winning the material is that of mining by drifting, but the conditions usually are good, as the roof materials are either tough shales or sandstones. Owing to the character of the material and the thickness of the deposits clay is mined much cheaper than coal. Ordinarily the cost runs between 25 and 50 cents per ton.

The quality of the Sciotoville clay in Jackson County is shown by the following tests. An analysis of the McKinniss fire clay is first given:[1]

Silica	53.55
Alumina	31.25
Sesquioxide of iron	trace
Lime	.65
Magnesia	.07
Potash and soda	.83
Water	13.35
Total	99.70

A partial analysis of a sample of this clay from near Bierlytown, kindly furnished by J. E. Jones, general manager of the Globe Iron Company, is as follows:

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[1] Geol. Surv. of Ohio, Rep. for 1870, p. 143.

Silica, SiO_2	43.26
Alumina, Al_2O_3	37.89
Ferric oxide, Fe_2O_3	1.71
Lime, CaO	.60
Magnesia, MgO	.20
Alkalies, K_2O and Na_2O	not det.
Ignition loss	14.40
Total	98.06

The above are analyses of flint clays, and compare favorably with those from this horizon in Scioto County, or near Olive Hill, Kentucky. The total fluxing components are under 5 per cent, and the silica-alumina ratio indicates high refractoriness. They are hard flint clays, similar in every respect to the typical clay in the Sciotoville region.

These beds in Jackson County have scarcely been touched. Near the Valley School, in Section 27, Hamilton Township, a small amount of clay was mined by benching and drifting, and was hauled by wagon to a brick plant at South Webster, in Scioto County. A few cars of clay were mined by stripping on the Flaker and Pratt properties in sections 9 and 16, Scioto Township. This was shipped to the brick works at Sciotoville, along with a small amount taken from the Lamb property in Section 6. The clay on the Howe land, Section 7, Coal Township, has been worked along the outcrop on the point of the hill. The deposits near Ray, in Section 1, Jackson Township, were worked in a small way also.

Future prospecting may show several fields in Jackson County where the clay has good volume and quality, and where the acreage is amply sufficient to warrant the establishment of brick plants. The proximate relations of coal and clay in this region are favorable conditions for manufacture. These clay deposits are worthy of careful examination and testing.

Economic Value of the Anthony Coal

In Jackson County the Anthony coal is of more interest for its stratigraphic relation than for its economic value, as it adds but little to the mineral wealth of the county. The best value is obtained when the Sciotoville clay below is of good quality, and both may be mined from the same entry. At only a few places is the bed of sufficient thickness to be mined, and at these it exists as local pockets of limited areas. At present it furnishes a small amount of house coal, dug usually by benching in the beds of the streams, or along their banks where the cover is shallow. In quality it varies from very pure coal to bone coal and to carbonaceous shales.

In Section 28, Hamilton Township, on land of R. A. Dever, the deposit is 3 feet thick, and has been mined from a short entry, but only a small amount of coal was removed. It has been benched from the bed of the creek on land of Vinton McCoy, in Section 11, and on that of J. M. Davis, in Section 12. Here the bed varies from 1 to 3 feet in thickness and the coal is of good quality. Near the McCoy Church it has been worked also, but the stratum is only 11 inches in thickness. In Section 4, on George W. Karn's land, the bed is divided into two benches, with a total thickness of 20 inches. This has been worked for local use. North of this, on Sugarcamp Creek, the deposit is represented by carbonaceous shales with thin coal bands. The next place of any considerable thickness is in Section 7, Coal Township, on the Samuel Anthony land. The thickness reported is 3 feet 6 inches, while that on the McKinniss land, in Section 6, is about 3 feet. It has been mined in a small way for local use in Sections 1, 2, and 12, Jackson Township.

The analysis of the Anthony coal from the Samuel Anthony land is as follows:[1]

Specific gravity	1.239
Combined water	5.25
Ash	1.50
Volatile matter	29.75
Fixed carbon	63.50
	100.00
Sulphur	.98
Sulphur remaining in coke	.37
Per cent of sulphur in coke	.57
Permanent gas per pound in cubic feet	3.00

GUINEA FOWL ORE

The Guinea Fowl ore is found on the same general horizon as the Sciotoville clay and Anthony coal, and the sections showing the relation of these members give the position of the ore, hence they will not be repeated here. The ore lies either directly or only a few feet above these members, and is only moderately persistent, as many wants are noted. In thickness it varies from a few inches to 2 or 3 feet, but averages 6 or 8 inches. Under heavy cover the iron is in the form of the carbonate, while along the outcrop or under shallow cover this has weathered to the hydrated oxides. The general characteristic of the ore is the high content of phosphoric acid and silica. In some samples the latter, in the form of quartz sand or quartz pebbles, or both, makes up a large part of the total volume. The composition, size and shape of the pebbles suggest that they were derived from the Sharon conglomerate, parts of which existed as land masses during the period of deposition of the ore. On account of its lean, siliceous nature, the ore was used but little by the charcoal furnaces. Compared to the high-grade Lake ores its value is low, but it may be used to some advantage where special grades of high phosphorus iron are desired.

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[1] Geol. Surv. of Ohio, Rep. for 1870, p. 140.

SANDSTONE NEAR SCIOTOVILLE CLAY HORIZON

In northwestern Scioto and southwestern Liberty townships, in some localities, there is a sandstone which is quite poor, varying in thickness from 10 to 30 feet, and occurring near the horizon of the Sciotoville clay. It is light colored, except where stained with iron oxides from surface weathering, and quite free from clay, mica, or other impurities. It is usually fine-grained. The quality approaches that of glass sand, and in the future the deposit may have some value.

QUAKERTOWN, JACKSON HILL, WELLSTON, OR NO. 2 COAL

The maximum development of the now known Ohio deposits of Quakertown coal is in Jackson County, where it has been worked since 1872. This bed has proved to be one of the county's most valuable assets, adding much to the wealth and activity of the region. The original field is largely worked out, but the production at present is of importance as the coal is of excellent quality, and thus commands the highest market prices. The area of the field is much larger than that of the Sharon, and the deposit is more regular and persistent. It is found at its best near Wellston and Coalton, where the stratum often reaches a thickness of 4 feet. This coal, free burning and low in ash, is quite generally recognized as superior for domestic purposes to any other found in this state.

Position

The Quakertown coal lies from 80 to 100 feet above the Sharon coal, while the average interval separating the two is about 90 feet. Its position above the Sciotoville clay is from 30 to 50 feet, with an average of about 40 feet. The interval from the Quakertown to the Bear Run coal above is from 20 to 30 feet, and to the Lower Mercer limestone almost 102 feet. When the full thickness of the Sharon conglomerate is considered, the Quakertown coal lies near the middle of the Pottsville formation.

Extent

The area of the known workable field of Quakertown coal in Jackson County approximates closely 40 square miles. In Lick Township the Quakertown coal is found near the summits of the highest knobs in the western part of Section 18. It extends eastward through sections 17, 16, and the parts of 21, and 15 north of the Baltimore & Ohio Southwestern Railroad. The coal, thin and bony, goes under cover near Young America Furnace, where it is present in the bed of the stream.

In Liberty Township the most western exposures noted are just west of the old Pine School, in Section 11, and north of this in Section 2. At these places the horizon of the coal is near the summits of the highest knobs, at an altitude of about 880 feet. The bed is also exposed at a number of places in sections 1 and 12. In Jackson Township the Quakertown coal was not found west of the deposit exposed near Canter's Caves, in sections 25 and 36. The deposits in this locality are from 860 to 900 feet above sea, and confined to the high knobs and ridges. From here the Quakertown coal extends eastward across Coal Township to Milton. It goes below drainage in the hollow east of Davisville, west of Altoona, in Section 34, and in the southwest part of Section 27. In Washington Township it is wanting or very thin west of Pigeon Creek, while east of this it is also poorly represented. On Glen Nell, at an elevation of about 780 feet, the coal is somewhat thinned and broken by the heavy overlying sandstone. Near the head of the hollow, east of Primrose School, in Section 16, the blossom exposed indicates a thin, bony bed, while along the Baltimore & Ohio Southwestern Railroad, in sections 10 and 15, the stratum is generally thin and uncertain, although it has been mined at a few places. On Sand Run, on the land of S. H. Ogier, it is found just above drainage, but was not observed east of this. In Milton Township the coal is reached by shafting only. In the old Marietta River Valley, near Wellston, the rock cover, excepting the fluvial deposits, is quite thin, but going eastward the dip of the strata soon carries the coal far below drainage. The existing workable area, from the present information obtained by drill records, is confined to the northern half of the township, and in a part of this the coal is unsteady.

The Quakertown coal is due above drainage in southern Lick, eastern Scioto, western Franklin, and eastern Hamilton townships, but here it is either completely wanting or represented only by a few inches of coal or bony shales.

Structure and Stratigraphy

The structure and regularity of a coal bed, the character of the roof and floor, and the utility of the associated materials, are all important in determining the value of a deposit. The Quakertown or Jackson Hill coal, in the main part of the field, is made up of a solid bench with no partings, but near the edge of the field the structure and character change. In the productive area the thickness of the stratum is quite regular. It is subject to local variations where rolls or arches in the floor are encountered, but no wants are found. The roof of the bed is tough shale, except in a few localities where this is replaced by sandstones, and the floor material is either a siliceous clay or a clay-bond sandstone. The associated materials have no exceptional value. The general relation of the Quakertown coal to other important members has been outlined above, but a more detailed report of the interval will be shown by numerous sections taken throughout the area.

Lick Township.—In Section 18, Lick Township, on the property of David Nicholls, the Quakertown coal has been mined near the summit of the hill, and the Sharon just below his house. The following section shows the various strata exposed for measurement:

	Ft.	In.
Coal, *Quakertown*, thickness reported	2	6
Covered	24	--
Sandstone, massive	33	--
Covered	5	--
Shale and parts covered	22	--
Coal, *Sharon*, thickness reported	2	8
Covered	2	--
Conglomerate, *Sharon*	40	--

In the same section, east of the above, a small area of Quakertown coal has been mined on the land of C. Mapes, where the bed is 2 feet 6 inches thick. In the northern part of the section, on the property of John M. Simpson, the following rocks were observed:

	Ft.	In.
Ore, kidney, reported thickness	--	4
Shales, gray	18	--
Coal, *Quakertown*	2	2

On a branch of Buffalo Skull Creek, Section 18, near the crossing of the Jackson and Chillicothe road, on land of Charles Walden, the strata were measured by Professor E. B. Andrews, and reported as follows:[1]

	Ft.	In.
"Hill coal," once mined, not measured.		
Not seen	59	--
Coal, "Anthony's Seam," not exposed for measurement.		
Under clay Conglomerate sandstone with iron ore Coarse sandstone Dark shales	36	--
Coal, highly laminated and resembling "Jackson Shaft coal," not fully exposed.		
Sand-rock.		

On the property of Mrs. J. G. McKittrick, in Section 17, the Quakertown coal has been mined on the hill north of the house, and a blossom, of what apparently represents the Sharon coal, is present on the road level near the house. Just north of this, on the property of Jonathan Cahorn, the Quakertown coal measured 2 feet 5 inches.

In Section 16 the Quakertown coal is found at the Crescent mine, which is in operation at present, while about 200 yards east the Bear

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[1] Geol. Surv. of Ohio, Rep. for 1870, p. 141.

Run coal was exposed in a ravine. The following section was taken at this place:

		Ft.	In.
Ore, black band, fossiliferous	*Bear Run*	--	4
Coal, bituminous		--	8
Bone, shale		--	6
Shales with parts covered		23	8
Coal, part bony, *Quakertown*		2	6

South of the above, and east of the main ridge, on the Simon L. David property, in Section 21, the Quakertown coal, only one foot in thickness, and the Bear Run coal were both exposed in the same hollow. The section recorded follows:

		Ft.	In.
Black band ore with thin coal bands, fossiliferous	*Bear Run*	--	6
Coal, bituminous		--	7
Coal, bone		1	--
Shale		1	--
Sandstone		3	--
Covered		11	--
Sandstone, shaly		5	--
Coal, weathered, *Quakertown*		1	--

In Lick Township, south of the Baltimore & Ohio Southwestern Railroad, the Quakertown coal disappears completely, or thins to a stain, but the Bear Run coal, with the black band ore and bone shale, is present in several localities. North of Young America Furnace, in Section 15, the Quakertown coal was seen in the bed of the stream near the residence of Mrs. J. Butts, and the Bear Run coal on the hill about 20 feet above. The Bear Run coal was also uncovered at several places farther up the stream. A composite section here is as follows:

		Ft.	In.
Limestone	*Lower Mercer*	--	10
Shale		2	2
Limestone		1	--
Covered		37	--
Coal blossom		1	--
Clay shale		4	--
Sandstone and covered		11	--
Sandy shale with thin sandstone		7	--
Shale, dark		4	--
Coal, cannel nature	*Bear Run*	--	9
Shale		--	2
Coal, cannel		--	2
Ore, black band, fossiliferous		--	3
Coal, bituminous		--	4
Sandstone		4	--
Shale		10	--
Coal blossom		--	3
Shale, blue, sandy		3	9
Shaly sandstone, plant marked		1	3

		Ft.	In.
Shale, sandy, with carbonate ore nodules		5	10
Coal, bony	*Quakertown*	--	4
Coal, good		--	9
Clay, bluish, sandy		1	6
Ore, irregular, kidney		--	5

The Quakertown coal is due in the corner of Lick Township southwest of Jackson, and what appears to mark its horizon is a thin layer of bone shales, with some cannel coal in places. A section taken just east of the furnace, on lands of the Jackson Iron & Steel Company and of Charles Ray, in Section 30, is as given below:

	Ft	In.
Ore, *Jackson Sand Block*, thickness reported	2	--
Shales, sandy	10	--
Sandstones, flaggy with small parts covered	36	--
Covered	4	6
Coal, cannel nature, bony, *Quakertown*	--	6
Clay and covered	2	--
Top of air shaft.		
Shales, sandstones and covered	60	--
Coal, *Sharon*, reported thickness	3	6

In the eastern part of the same section, on land of J. J. McClung, the Bear Run coal has been mined in a small way, while the blossom of the Quakertown is seen in the hollow to the south. The section taken is as given below:

	Ft.	In.
Coal, *Bear Run*	2	--
Sandstone, flaggy and parts covered	30	--
Shale, blue	2	--
Coal, cannel nature, *Quakertown*	--	6

This cannel coal goes under cover near the southern boundary of the township, but the Bear Run and Vandusen coals above are found in a number of localities. No section was obtained, however, showing the three coals in the same interval.

Scioto Township.—In Scioto Township the Quakertown coal, represented by a few inches of a bony cannel coal, was observed at a few points. On the property of T. A. Henderson, in Section 1, the rocks exposed are recorded below:

	Ft.	In.
Ore, fossiliferous, probably derived from weathering of *Lower Mercer* limestone	--	6
Covered	86	--
Ore, *Jackson Sand Block*, reported thickness	1	--
Covered	8	--
Carbonaceous shales with coal bands, *Bear Run* coal horizon, reported thickness	2	4
Shales	8	--
Sandstones, flaggy	24	--

	Ft.	In.
Covered	5	--
Coal, *Quakertown*, cannel nature, reported thickness	--	6

The blossom of coal on this horizon was seen in a few other localities in Scioto Township, but nowhere was the deposit found to have any considerable thickness. In Hamilton Township also, only thin stains representing the Quakertown coal were observed, while in much of the territory even these are wanting.

Liberty Township.—In Liberty Township the Quakertown coal is found in good thickness near the summits of the high hills and ridges in the northeastern part. In Section 13, on the land of Louis Ray, both the Quakertown and Sharon coals have been mined, and the Sciotoville clay, lying close above the Sharon coal, is also found. A section measured here follows:

	Ft.	In.
Coal, *Quakertown*, reported thickness, quality also reported good	2	6
Covered	58	--
Sandstone	10	--
Clay, flint } *Sciotoville*	1	2
Clay, soft } *Sciotoville*	1	10
Coal blossom, *Sharon*	1	--
Clay, dark, siliceous	2	--
Conglomerate, *Sharon*	91	--

On the land of Elmer Richard, in Section 12, the blossoms of both the Quakertown and Sharon coals were exposed with thicknesses of 3 and 2 feet respectively, and are separated by an interval of 70 feet. Along the ridge in the northwestern part of this section Quakertown coal is mined for local use. On the farm of Alfred Poe it measured 3 feet 4½ inches in thickness. The Quakertown coal is also mined on land of Samuel Montgomery, in Section 11, for a local supply. The coal is of excellent quality, and Mr. Montgomery reports that the stratum in this locality measures from 2 feet 6 inches to 2 feet 8 inches, but in places thickens to nearly 4 feet. The blossom of the Quakertown coal was uncovered in the road near the old Pine School, and below, on land of W. B. Steffy, the bony blossom of the Sharon coal, lying on the massive conglomerate, was exposed in the bed of a small stream. The section measured gave the following relations:

	Ft.	In.
Coal blossom, *Quakertown*	2	--
Clay shale	4	--
Sandstone, soft, with parts covered	45	--
Sandstone and covered	23	--
Sandstone, conglomeratic, ferruginous	13	--
Shale, dark, carbonaceous, *Sharon* coal horizon	3	--
Conglomerate, *Sharon*	110	--

On land of D. D. Edwards, in Section 2, a record was obtained which shows the positions of the Sciotoville clay and Sharon coal with reference to the Quakertown coal. The measurements taken are as follows:

	Ft.	In.
Coal, *Quakertown*	3	6
Clay shale	1	6
Covered	42	--
Sandstone, ferruginous	2	--
Sandstone, ferruginous, with large pebbles, horizon of *Guinea Fowl* ore	1	--
Clay, flinty, siliceous } *Sciotoville*	1	6
Clay, light, plastic	10	6
Sandstone and covered	23	--
Shale with thin, ferruginous sandstone layers	5	--
Sandstone, shaly	5	--
Shale, blue	7	--
Coal, shaly, *Sharon*	--	4
Clay, blue	2	6
Covered	4	--
Conglomerate, *Sharon*	90	--

In Section 1, on the property of James Wilson, the Quakertown coal is mined for local use, and measured 3 feet 1 inch. In the same section, east of Little Salt Creek, the Quakertown coal is present on the main ridges, but no good exposures were found.

Jackson Township.—In Jackson Township the Quakertown coal is confined principally to the high ridges and hills in sections 25 and 36. The deposit in this locality has good thickness and the coal is of excellent quality. In Section 36, on land of William McKinniss, coal is mined for local use. The record obtained here shows the following rocks:

	Ft.	In.
Coal, a few inches of cannel coal found in upper part of bed in places in the mine, *Quakertown*	3	6
Coal, bony	--	5
Covered	62	--
Sandstone	6	--
Shale, gray	2	--
Shale, dark, carbonaceous, *Sharon* coal horizon	1	--
Shale, gray, siliceous	1	--
Conglomerate, *Sharon*	80	--

In Section 25, on land of John Spanover, the blossom of the Quakertown coal, and an ore that occurs frequently above the coal horizon, were exposed along the road. The measurements of the rocks follow:

	Ft.	In.
Sandstone, micaceous	10	--
Ore, nodular, siliceous	--	3
Shales	20	--
Coal blossom, *Quakertown*	1	--

On the knob north of Canter's Caves, on land of Lawrence Harris, the Quakertown coal has been opened. This is the most western exposure found in southern Jackson Township, and the coal, where observed, was 1 foot thick. This bed has been mined for local use on the farm of W. A. Johnson, but the thickness was not determined. The section given below was measured from an exposure of Quakertown coal on land of C. W. Haslett, to the hollow east:

	Ft.	In.
Coal, *Quakertown*	3	--
Covered	88	--
Sandstones, with layers of shales	10	--
Shales, sandy	15	--
Shales, carbonaceous, with thin coal bands, horizon of *Sharon* coal	1	--
Clay, light, siliceous	1	--

North of this there are a few knobs and ridges, whose elevations are such that the horizon is due on them, but the Quakertown coal is either very thin, or replaced by the heavy coarse-grained sandstone, for no coal of any considerable thickness was found. The heavy sandstone present on these ridges is the same as that seen at Richland Furnace.

Washington Township.—The Quakertown coal is unsteady in Washington Township, for in only a small part of the territory the stratum is represented by coal of minable thickness. In some localities it is entirely replaced by heavy sandstones, and in others it is made up of bone shales with thin coal bands. The tracing of the Quakertown coal, and various other members, from the Coalton field north to the coal bed found near the level of the Baltimore & Ohio Southwestern Railroad, in sections 10 and 15, and from this point southeast to the Quakertown coal in the Wellston field, shows that the deposit in sections 10 and 15 is on the same stratigraphic level as that of the Quakertown coal in the Wellston and Coalton fields, and that it is evidently correlative, as it bears also the same general relations to various other members as does that of the known Quakertown. In the locality specified above, the average of six measurements from the coal to the Lower Mercer ore gives an interval of 103 feet, while the average for all the measurements taken in the entire Quakertown field gives an interval of 102 feet from the known Quakertown coal to the Lower Mercer ore or limestone. As near as could be determined the horizon of this coal bed is about 30 feet above the Sciotoville clay deposits seen north of Richland Furnace, and this position also identifies it as Quakertown coal. At Glen Nell, in sections 20 and 21, both the Sharon and Quakertown coals have been mined. A composite section taken from here to the summit of the hill near the Town House, where the Black Flint outcrops, covers nearly the entire Pottsville formation. The section given below shows the members exposed and the measurements recorded:

	Ft.	In.
Flint, dark, fossiliferous, just below the horizon of the Brookville coal	1	--
Shale and covered	18	--
Shale	3	--
Coal blossom, *Tionesta*	1	--

	Ft.	In.
Clay, sandy	2	--
Sandstone, soft, micaceous	37	--
Covered	14	--
Shale, dark blue	6	--
Coal, *Upper Mercer*	1	--
Shale, dark, carbonaceous	3	--
Shale, sandy	8	--
Covered	4	--
Sandstone	12	--
Ore, *Lower Mercer*.		
Covered	75	--
Sandstone	5	--
Coal, irregular, wanting in places, probably part of *Quakertown* coal	--	6
Sandstone	3	2
Sandstone and sandy shale	3	6
Coal, *Quakertown*, very irregular, with sandstone cutting into it	2	6
Shale and covered	61	--
Sandstone, coarse-grained	12	--
Ore, *Sharon*, with pebbles, fossiliferous	--	7
Shale, dark, carbonaceous	--	4
Coal, *Sharon*	3	1
Covered	3	--
Conglomerate, *Sharon*	15	--

In Section 16, near the Primrose School, Sharon coal is mined in a small way for local use. Along the road that leads to the ridge east of this a blossom of coal is exposed near the foot of the hill which correlates as Quakertown. The composite section obtained here, and given below, shows much the same relations as that taken at Glen Nell:

		Ft.	In.
Top of high knob, and horizon of *Black Flint*.			
Shale and covered		20	--
Coal blossom, *Tionesta*		--	2
Sandstone, massive		45	--
Coal blossom, *Upper Mercer*.			
Covered		38	--
Sandstone, massive		45	--
Finger coal in sandstone.			
Shale, sandy		12	--
Sandstone, shaly		17	--
Coal blossom and dark shale, *Quakertown* horizon		1	--
Clay, dark		2	--
Covered interval, only approximate		63	--
Sandstone, shaly, dark blue		4	--
Coal, bony	*Sharon*	--	3
Clay, shale		--	1
Coal, bony		--	5
Clay, shale		--	2
Coal, bony		--	4
Clay, shale		--	1
Coal		--	6
Clay, shale		--	2
Coal		1	2

Near the level of the railroad track in Section 15, on the land of W. W. Manning, the coal has been opened, and a small quantity of fuel mined. A composite section taken on land of W. M. Walburn, in Section 10, shows the following relations:

	Ft.	In.
Ore, *Sand Block*	--	4
Covered	17	--
Ore, *Lower Mercer*	--	6
Shale and covered	48	--
Sandstone and covered	20	--
Sandstone	22	--
Coal, reported thickness, *Bear Run*	1	--
Sandy shale and shaly sandstone	23	--
Covered	2	--
Coal blossom, *Quakertown*	1	--

On land of W. W. Manning, this coal, and also the Lower Mercer, have been mined for local use. The carefully taken section here shows the following members which were exposed, and the intervals separating them:

	Ft.	In.
Ore, on *Black Flint* horizon.		
Sandstone and covered	30	--
Covered	10	--
Sandstone and covered	35	--
Covered	20	--
Ore, *Lower Mercer*.		
Shale and covered	27	--
Coal, *Lower Mercer*	2	4
Sandstone	15	--
Covered	23	--
Coal blossom, thickness reported	1	--
Sandstone and covered	36	--
Coal } *Quakertown*; reported thickness	1	8
Clay	--	4
Coal	--	6

On land of S. H. Ogier, in Section 14, the Quakertown coal has been opened just above the level of Sand Run, and is reported by Mr. Ogier to have a thickness from 2 feet 2 inches to 2 feet 4 inches. A section taken there follows:

	Ft.	In.
Limestone, *Lower Mercer*	1	--
Covered	101	--
Shale, gray	8	--
Coal, *Quakertown*, reported thickness	2	2

A section taken from the Superior Coal Company's Mine No. 2, to the summit of the knob on land of E. C. Wallace, shows a number of important members above the Quakertown coal. The section obtained is recorded below:

	Ft.	In.
Sandstone and covered	30	--
Shale	10	--
Ore, *Black Flint* horizon	--	6

	Ft.	In.
Shale, lower part very fossiliferous	10	--
Coal blossom, *Tionesta*	--	6
Sandy clay and covered	3	6
Sandstone	38	--
Ore nodules and flint, *Upper Mercer*	--	4
Shale, gray	13	6
Coal blossom	--	6
Clay, light, sandy	2	--
Sandstone, shaly	7	--
Shale, gray	6	8
Ore, sandy	--	4
Sandstone, ferruginous	2	--
Clay, light, sandy, *Upper Mercer* coal horizon	5	--
Shale, gray	4	--
Sandstone, shaly	2	8
Shale, gray	--	10
Ore, *Lower Mercer*	--	2
Shale, gray	2	4
Sandstone, light, shaly	3	--
Shale, dark	9	--
Shale, sandy and with thin coal bands	3	--
Shale, blue	1	2
Cannel coal, shaly, *Lower Mercer*	--	10
Clay shale	1	--
Covered	5	--
Sandstone, with parts covered, and with irregular lenses of coal in lower part	37	--
Disconformity.		
Shale, dark blue	5	--
Top of air shaft.		
Interval reported	35	--
Coal, *Quakertown*, reported	2	6

In Section 24, on land of Clyde Foster, the Quakertown coal was formerly mined by shaft, and the Lower Mercer coal has been opened on the hill above.

Coal Township.—In Jackson County the Quakertown coal has its maximum development in Coal and western Milton townships. This area has been the center of mining activity for about 40 years, and, although the best of the field is practically exhausted, the bed is yet an important asset to the region, as it yields a good supply of most excellent fuel. In Coal Township the stratum has good thickness and continuity, and extends over practically the whole area.

In Section 7, near Bierlytown, on the Arthur Howe property, the Quakertown coal, found near the summit of the hill, and the Sciotoville clay, of good quality, about 45 feet below, have both been mined. Below the latter, black shales on the Sharon coal horizon have been prospected. A section taken here follows:

	Ft.	In.
Coal, *Quakertown*, reported thickness	1	3
Covered	31	--

	Ft.	In.
Shale, sandy, with thin sandstone layers	13	--
Clay, flint, good quality, *Sciotoville*	5	--
Covered	9	--
Sandstone, massive	11	--
Shale	3	--
Black shale and covered, *Sharon* coal horizon	8	--
Clay shale, sandy, light	5	--
Covered	37	--
Conglomerate, *Sharon*	25	--

On the property of Louis Mapes, in the central part of Section 7, the same members are represented as shown below:

	Ft.	In.
Coal, *Quakertown*, reported thickness	3	--
Covered	38	--
Clay, flint, good quality, *Sciotoville*, reported thickness	3	--
Covered	21	--
Sandstone with a few pebbles in places	27	--
Coal, *Sharon*	1	--

In the southeast corner of Section 7, on the property of John W. Simpson, the following rocks were exposed for measurement:

	Ft	In.
Shales, black, tough, *Bear Run* coal horizon	1	--
Sandstone	--	6
Clay shales	2	--
Shales, parts covered	6	6
Ore, reported thickness	--	4
Shales, gray and parts covered	21	--
Coal, *Quakertown*	2	4

On the Charles McKinniss land, in Section 6, the Quakertown and Anthony coals have been mined, and the Sciotoville clay, very flinty, and of good quality, was exposed in the road near where it crosses the stream. A section here is as given below:

	Ft.	In.
Ore, sandy, *Lower Mercer*	--	4
Shale and covered	13	--
Ore, kidney	--	2
Shale	--	10
Limestone, *Lower Mercer*	--	6
Shale	1	6
Coal blossom	--	2
Clay, light, plastic	2	--
Covered	18	--
Sandstone	4	--
Shale	1	--
Coal blossom, *Lower Mercer*	--	1
Clay, shale, light	3	--
Sandstone and covered	18	--
Covered	13	--
Shale	24	--
Coal, *Quakertown*	2	6
Covered	4	--

	Ft.	In.
Sandstone	3	--
Coal	--	6
Clay, plastic	4	6
Shale, dark	6	--
Covered	8	--
Sandstone	2	--
Shale, gray	9	--
Coal blossom, *Anthony*, reported 3 ft. thick under cover	--	6
Covered	3	--
Coal blossom	--	2
Clay, flint, good, *Sciotoville*	3	6

In Section 31, on the land of Gilbert Lucas, the Quakertown coal has been opened, and is reported to be from 2 feet 6 inches to 2 feet 8 inches in thickness. Along this ridge, on lands of the above mentioned party and C. W. Haslett, there is a small area of unworked coal, which, from surface indications, and reported results of prospecting, has good thickness and value. In Section 30 the Quakertown coal is thin or wanting. In the northern part of Section 29 the stratum is thin and unsteady. Jacob Sells operates a wagon mine on his property in Section 32. He reports the bed in the territory now worked to vary in thickness from 2 feet 5 inches to 3 feet 2 inches, and to average 2 feet 8 inches. The coal here is of excellent quality. The Lower Mercer limestone is found on the summit of the high hill west of his residence, and the interval to the coal somewhat above the average, is 127 feet.

On the Sells property, on the hill south of the pike, he reports that in a part of the area cannel coal makes up the upper part of the stratum, and locally the entire bed is cannel coal of superior quality, which in some places has a thickness of 4 feet. This at present is exhausted, as the deposit was local, not carrying in force even to the adjacent properties. In the same section south of this, at the railroad mine of the T. J. Evans Coal Company, the stratum is reported in places to be very thin, while in other parts of the mine it thickens to 3 feet. In Section 8, at the mine of the Jackson Hill Coal Company, the interval from the coal to the Lower Mercer limestone on the knob north is 115 feet by aneroid measurement.

In Section 4 most of the coal area is practically exhausted, but small amounts are yet mined for local use. On land of Samuel Richard the coal measured 2 feet 11 inches, which is about the general thickness of the Quakertown bed found in the large mines formerly operated in the region. The field near Coalton formerly yielded a large supply of coal, but the quantity produced at present is small. In Section 33, on land of John F. Shook, the section obtained and given below shows the interval from the Quakertown coal to the Lower Mercer limestone:

	Ft.	In.
Limestone, *Lower Mercer*	1	--
Shale and covered	30	--

	Ft.	In.
Sandstone with parts covered	64	--
Shale with parts covered	13	6
Coal, *Quakertown*	2	6

A small wagon mine is operated on land of W. R. Hamilton, in Section 28, where the coal measured 2 feet 6 inches in thickness. The stratum is reported to vary from 1 foot 8 inches to 2 feet 8 inches. North of this, at the mine of the Buckeye Coal Company, which is nearing exhaustion, the coal measured 2 feet 6 inches. The coal in this locality is reported to vary from 2 to 3 feet, but to average about 2 feet 6 inches. The heavy sandstone above forms the roof of the mine in places. Along the road in the western part of Section 27 this sandstone was found lying close above the coal, and in local areas replacing it. The disconformity noted at the base of this sandstone seems to account for the unsteadiness of the coal northward, as the deposit is wanting, thin, or broken into benches, with irregular sandstone partings. In Section 34 a few mines are yet operated, but the main body of coal is exhausted. Here the continuity and thickness of the bed are very good, as they are also to the south in Section 3.

The Quakertown and Bear Run coals were seen on the property of M. H. Harrison, in Section 8, Coal Township, where both have been mined. The relation is as given below:

	Ft.	In.
Coal, *Bear Run*, reported cannel with fissile shale	2	--
Covered	19	--
Shale, blue	4	--
Ore, kidney	--	3
Shale, blue	6	--
Coal, *Quakertown*	3	--

The coal in the Chapman mine measured from 2 feet 6 inches to 3 feet 4 inches. In the Glenroy area the Quakertown coal has an average thickness of 3 feet 4 inches, with a maximum of 4 feet and a minimum of 2 feet 6 inches.

In the southeastern part of the section the coal thins and becomes bony, while south of this, in Lick Township, it disappears completely. A composite section, taken along the road from near Young America Furnace, north to the summit of the hill near the house of R. L. Channell, in Section 10, shows the following members and the condition of the Quakertown coal:

	Ft.	In.
Shale	4	--
Coal blossom, *Upper Mercer* or *Webster Block*	--	6
Clay	2	6
Shale	8	--
Coal blossom.		
Clay shale	1	6
Shale	5	--

		Ft.	In.
Ore, *Lower Mercer*		--	5
Shale, sandy, blue		12	--
Limestone, fossiliferous	*Lower Mercer*	--	6
Shale, dark		1	6
Limestone, fossiliferous		1	--
Shale, blue		3	--
Covered		7	--
Coal blossom, *Lower Mercer*		--	3
Shale, dark		1	--
Shale, gray		1	9
Covered		12	--
Shale and covered		8	--
Coal blossom		1	--
Clay		--	6
Shale, dark carbonaceous		1	6
Clay shale, light		3	--
Sandstone, shaly		11	--
Shale, blue		13	--
Covered		4	--
Sandstone		4	--
Shale		--	8
Coal, cannel nature	*Bear Run*	--	11
Shale, dark		--	1
Coal, blocky, bituminous		--	11
Sandstone		4	--
Shale		10	--
Coal blossom		--	3
Shale, blue, sandy		3	9
Sandstone, shaly, plant marked		1	3
Shale, sandy, with ore nodules		5	10
Coal, bony	*Quakertown*	--	4
Coal, good		--	9
Clay, bluish, sandy		1	6
Ore, irregular kidney		--	5

In the southern parts of sections 11 and 12 the Quakertown coal is reported thin and bony, while in sections 1 and 2 the available supply is not large. In sections 35 and 36 the bed is reported to have excellent thickness, but at present the mines are worked out. In Section 26 the Superior Colliery Company still operates its No. 3 mine, but the future supply is relatively small. At present there is one railroad mine which still has a small undeveloped territory in Section 25.

Milton Township.—From Coal Township the Quakertown coal extends eastward into Milton, and in fact it is reported that the best of the entire field in Jackson County was that part originally worked in the vicinity of Wellston, where the bed has a regular thickness of about 4 feet. The coal in this area has excellent quality, and is now exhausted, except small blocks left in the old mines where the cover is shallow, or the dip such as to cause trouble from water. As the Quakertown coal extends eastward from Wellston, there is a general gradual thinning of the stratum, but no drill records defining the eastern border of the field were obtained. From reports, the southern extension of thick coal is within the northern half of the township. Future drill work may locate other small areas in the eastern part of the county.

The Brown Coal Company operates a small railroad mine north of Wellston, in Section 31, Milton Township, but no record of the strata was obtained. In sections 6 and 7, the bed is practically exhausted, and the mines abandoned. The Domestic Coal Company operates a mine in Section 32, north, where the following measurements were obtained:

	Ft.	In.
Limestone, *Ferriferous*	5	--
Coal blossom, *Clarion*	4	--
Clay and shale	5	--
Coal blossom, *Brookville*	2	6
Clay and covered	8	6
Covered	17	--
Sandstone	5	--
Covered	38	--
Sandstone	11	--
Coal, *Upper Mercer*	--	6
Sandstone	20	6
Sandstone, shaly	10	--
Limestone, *Lower Mercer*	1	--
Covered	4	--
Top of shaft.		
Shaft depth	87	--
Coal, good Coal, bony } *Quakertown*	3 --	-- 4

The thickness of the coal is reported to vary from 2 feet 6 inches to 3 feet 10 inches. At the mine of the Wellston Colliery Company, in Section 5, the average thickness of the bed is 2 feet 6 inches. The coal in this mine is reported to vary in thickness from 1 foot 10 inches to 3 feet. The quality of the fuel is very good. In Section 8 good blocks of coal, which were left by the unsystematic way in which the mines were formerly operated, are reported to be present, while in sections 17 and 18 some undeveloped territory is found. A drill test made in the eastern part of Section 18 by the Superior Colliery Company shows that the Quakertown coal has good volume in this locality, as it is 3 feet 2 inches thick. In Section 33 a composite section, taken from the No. 12 mine of the Superior Colliery Company, to the hill west, and given below, shows the most important members from the Lower Kittanning to the Quakertown coal:

Summit of ridge.	Ft.	In.
Covered	5	--
Ore, kidney	--	2
Shale and shaly sandstone	19	--
Coal blossom, *Lower Kittanning*	2	--

	Ft.	In.
Clay and covered	15	--
Shale and shaly sandstone	8	--
Ore, irregular, *Ferriferous*	--	5
Limestone, *Ferriferous*, with parts covered	8	--
Coal blossom, *Clarion*	4	--
Clay, sandy	5	--
Sandstone, shaly	10	--
Covered	4	6
Coal blossom, *Brookville*	--	6
Light clay and clay-bond sandstone	7	--
Sandstone	5	--
Covered	6	--
Shale, sandy	7	--
Shale with ore nodules	--	4
Shale	--	8
Coal, shaly, *Tionesta*	--	6
Clay, light, plastic	2	--
Sandstone, shaly	2	--
Ore, sandy, nodular	--	6
Sandstone, massive, soft, cross-bedded	51	--
Top of shaft.		
Sandstone	10	--
Coal, *Upper Mercer*	1	--
Sandstone, shaly	7	--
Interval	147	--
Coal, bony } *Quakertown*	--	2
Coal, good }	2	6

Mr. Richard Samuel, Jr., reports the coal in the Wainright mine of the Maynard Coal Company to vary in thickness from 1 foot 8 inches to 3 feet 8 inches, but to average 2 feet 2 inches. The quality of the coal here is very good, and the stratum is quite free from bone or shaly partings. South of the above, in Section 9, at the No. 9 mine of the Superior Colliery Company, the measurements obtained are given below:

	Ft.	In.
Coal blossom, cannel, *Tionesta*	1	--
Covered	24	--
Coal blossom	--	6
Clay	1	6
Covered	6	--
Ore, *Upper Mercer*.		
Covered	59	--
Top of shaft.		
Interval	138	--
Coal, *Quakertown*	2	8

The bed in this mine is reported to vary in thickness from 1 foot 10 inches to 4 feet, but to average about 2 feet 6 inches. There are local rises or rolls in the floor of the mine, upon the summits of which the coal thins. The mine of the Elk Fork Coal Company, in Section 3, is the most eastern mine working the Quakertown coal. The record obtained here is as follows:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Shale, sandy	9	2
Coal, *Upper Mercer*	1	6
Sandstone, shaly	5	--
Top of shaft.		
Sandstone and covered	25	--
Limestone, *Lower Mercer*	1	--
Shale	7	--
Coal	--	4
Interval	89	--
Coal, *Quakertown*	2	3

In this locality the thickness of the coal is quite constant, varying only from 2 feet 2 inches to 2 feet 4 inches, and the quality is excellent. South of this, in Section 10, the Quakertown coal is also present in good volume, as the drill record furnished by the Superior Colliery Company shows 3 feet of good coal, underlain by 1 foot of bone coal. A record also furnished by the Superior Colliery Company shows the general condition of the Quakertown coal in Section 13. The driller's log follows:

	Ft.	In.
Surface	19	--
Limestone, [*Ferriferous*]	16	--
Shale	4	--
Coal, [*Clarion*]	4	--
Clay	4	--
Shale, gray	6	--
Sandstone	27	--
Shale	8	--
Coal, [*Tionesta*]	1	6
Clay	3	--
Shale, gray	18	6
Sandstone	36	--
Shale, gray	26	--
Shale	--	3
Coal, [*Lower Mercer*]	--	6
Clay	2	--
Sandstone	59	6
Shale, light	14	--
Shale, dark	1	--
Clay	2	--
Sandstone	35	--
Shale	1	9
Coal, *Quakertown*	4	--
Clay	--	8

Terms in brackets were supplied by the writer.

Near the head of Rich Run, in Section 12, a shaft was sunk for the Quakertown coal, but no records or information concerning it were available. South of this there has been some testing by the core drill, but the records were not obtained.

Economic Value

The Quakertown coal is an asset of importance to Jackson County, for the bed has yielded during more than 40 years of mining, a greater revenue than any other member, far surpassing that of the Sharon coal, its nearest rival. Wellston, Coalton, and the villages adjacent, owe their rise to the Quakertown coal, which has also been an important factor in the development of Jackson. Although the best of the field is practically exhausted the known area of thin coal, averaging between 2 and 3 feet, is at least 10 square miles, and future drill work may extend this area, or reveal outlying pockets. The average thickness of the bed in the six mines now operating east of Wellston is 2 feet 6 inches.

The Quakertown bed, although it may be thin, has several features which aid considerably in its mining. The stratum is, with few exceptions, clean coal, i. e., it is seldom broken by bony or shaly partings, and even where these are present they lie either on the top or the bottom of the deposit, so they may be separated without difficulty. Sulphur concretions or bands are not common. Owing to these features the mined coal is clean and bright, and thus it goes into the market in good condition. The roof material is usually a thick tough shale, although in a few localities it is sandstone. This shale forms a safe roof, and allows a high percentage of the total coal to be mined. The mines are seldom troubled with draw slate or horsebacks, but rolls or local dips are occasionally encountered. The floor material is a rather hard siliceous clay, which makes a good footing for posts and pillars, and does not work up easily into plastic mud along the haulways. No tests were made of this clay, but from general appearance it is fitted for light and buff building brick. Where the coal is thin about 2 or 3 feet of this clay is removed from the main haulways, and it may be used with some economy for ceramic products, for at present the cost of mining it is a direct loss. The high quality of the coal, the freedom from partings, and the character of the roof and floor, enable the Quakertown bed to be mined at a low cost, even where the stratum is thin.

In general, the mines at present are worked by the single entry system, and the rooms turned from the cross entries. Induced circulation of air is produced by fans. The coal is cut both by hand and machines, but in most of the larger mines the latter method is used. The electric machines in general use are Jeffery, Morgan-Gardner, and Goodman. The coal is gathered by mule power, except in the mine of the Elk Fork Coal Company, where storage battery motors are used very successfully. This motor, designed and patented by C. K. Davis, does away entirely with mule power, and is constructed to gather coal in low workings. The mine foreman reports that the motor is very reliable, and able to do a large amount of work at a low cost per ton of coal. In all the large mines the main haulage is by motors; the types in general use are Jeffrey, Morgan-Gardner, and Westinghouse.

The railroad mines in operation in 1914 were as follows:

Name of Mine.	Name of Operator.
Armstrong	Armstrong Coal Company, Jackson.
Crescent	Evan Roberts.
Chapman	Chapman Coal Company.
Grace	
Springfield	
Buckeye	The Emma Coal Company.
Jackson Hill	
Emma No. 2	
Bat's Nest	Glen Roy Coal Company.
Hurd Shaft	C. A. Sloan Coal Company.
Victor No. 3	T. J. Evans Coal Company, Coalton.
Victor No. 4	
Hurd Slope	Harper Coal Company.
Twin-Ada	Twin-Ada Coal Company.
Rowe	Rowe Coal Company.
Rhodes	Rhodes Coal Company.
Alburn	Alburn Coal Company, Wellston.
Elk Fork	Elk Fork Coal Company.
R. & W.	R. & W. Coal Company.
Domestic	The Domestic Coal Company.
Milton No. 1	Milton Mining Company.
Superior No. 3	Superior Colliery Company.
Superior No. 4	
Superior No. 9	
Superior No. 12	
Colliery	The Wellston Colliery Company.
Price	W. A. Gosline & Company, Toledo.
Wainright	The Maynard Coal Company, Columbus.

A brief description of some of the mines in the region follows:

The T. J. Evans Coal Company operates a level-free mine about one mile west of Coalton. About 25 men are employed, and the output is about 70 tons per day. The coal is hauled by mule power, but the pumps and fans are operated by steam. They are driving their main entries westward into new territory. In this region coal is also hauled to the cars by wagon from the Jacob Sells and other small mines. The Buckeye mine of the Emma Coal Company, located in Section 28, Coal Township, is nearing exhaustion. It is a level-free mine, using mule power for hauling the coal, and steam only for running the fans and pumps.

Between Coalton and Jackson there are several mines still in operation, some of which have undeveloped territory, while others are only drawing pillars in old workings. The Emma Coal Company is drawing pillars from its Jackson Hill mine in Section 8. The Price mine of W. A. Gosline & Company, in the same section south of this, is practically abandoned. The Grace and Hurd Shaft mines, in Section 10, are working mainly in old territory, but report large blocks of unworked coal. The level-free Chapman mines, in Section 9, report some unworked territory. The Armstrong and Crescent mines, in Section 10, Lick Township, have undeveloped territory, but the coal is somewhat bony.

The coal in the mines east of Coalton and near Glenroy, although they are located in worked territory, is not yet exhausted. Owing to the unsystematic way in which the field was originally mined large quantities of coal are available from the old works and from isolated blocks of solid coal which were left for various reasons. The annual tonnage of the Twin-Ada mine, which is located in the heart of the original Quakertown field in Jackson County, is about 10,000 tons. The fuel is of exceptional purity, and the bed has an average thickness of 3 feet 4 inches. This company reports that it has yet a solid block of coal with an area of 25 acres, besides heavy pillar coal in many acres of old works. The No. 4 mine of the Superior Colliery Company, located in Section 1, Coal Township, has good areas of undeveloped territory in sight, and many pillars in the old part of the mine which will also furnish large quantities of fuel. The mine, which is a shaft 96 feet in depth, has a daily capacity of 200 tons, and is situated on the Cincinnati, Hamilton & Dayton Railway. The coal bed is from 2 to 4 feet in thickness, but it has an average measurement of about 3 feet.

West of Wellston two railroad mines are in operation. The No. 3 mine of the Superior Colliery Company, in Section 26, Coal Township, has a daily capacity of 200 tons. The coal varies from 2 to 4 feet in thickness. The best of this field is largely exhausted. Both mines are reported to have areas of thin coal which will last for several years.

The main body of Quakertown coal at present lies east of Wellston. The Brown Brothers operate a small shaft mine just north of the town, but the area is small and the coal thin. In Section 32, Milton Township, the Domestic Coal Company operates a shaft mine connected by switch to the Detroit, Toledo & Ironton Railway. The mine is equipped with modern mining machinery, and has a capacity of 300 tons per day. They report 66 acres of unworked territory ahead, and the present workings are not yet exhausted. The bed in this locality has good thickness, and the coal excellent quality. The mine of the Wellston Colliery Company is located in Section 5, and connected by switch to the Cincinnati, Hamilton & Dayton Railway. The mine is electrically equipped, using electricity for lighting, hauling, and cutting. The pumps, fans, and hoisting machinery are run by steam. They report a good area of thin coal, and a block of thick coal ahead.

The Wainright mine, operated by the Maynard Coal Company, is located in Section 4, and connected by switch to the branch of the

Detroit, Toledo & Ironton Railway. The mine is equipped with modern machinery. They report a good area of coal averaging about 2 feet 2 inches in thickness, and also a block of thick coal almost 3 feet 6 inches in thickness. The Superior No. 12 mine of the Superior Colliery Company is located in Section 33, and connected by switch to the Detroit, Toledo & Ironton Railway. The mine is equipped with inclined and shaker screens, Mitchell dump, steam hoist, Jeffrey electric cutting machines, and Morgan-Gardner motors. The coal is gathered by mule power. The capacity of the mine, when running full, is 300 tons per day. They report an area of coal averaging about 2 feet 6 inches in thickness, sufficient to last for a number of years.

The mine of the Elk Fork Coal Company is located in Section 3, Milton Township, and on the branch line of the Detroit, Toledo & Ironton Railway. The equipment is modern and the mine more carefully managed than any other in the region. Storage battery motors instead of mules are used here for gathering the coal. The output is about 100 tons per day. The bed here, although thin, is very uniform, ranging from 2 feet 2 inches to 2 feet 4 inches, and the coal is of excellent quality. The area ahead is reported large.

The Superior No. 9 mine of the Superior Colliery Company is located in Section 9. The shaft, 138 feet deep, is equipped with steam hoisting machinery. Steam is used also for the pumps and fans. The hauling and cutting is done by electricity, but the gathering by mule power. The stratum in this locality varies considerably in thickness. The mine foreman reports the bed to expand from 2 feet 10 inches to 4 feet, but to average about 2 feet 6 inches. He also reports a large area ahead, the boundaries of which are not definitely known. This is the most southern mine east of Wellston.

The quality of the Quakertown coal ranks it as one of the very best domestic coals in this state, and on a par with the best of those in West Virginia and Pennsylvania. On account of its merit, it has long enjoyed a wide reputation in the western and northern markets, and has commanded the highest prices. With few exceptions, the bed is free from shale and clay partings, and from pyrite nodules and bands. It mines clean, and on standing discolors but little, as the amount of pyrite and clay present is very low. There is also only a small amount of "mother coal" in the stratum which differs in this respect from the Allegheny coals in the region. It is a free burning coal, igniting readily, but producing good heat and lasting quite well. It burns freely from the time lighted until consumed. The amount of smoke produced is low, considering the amount of volatile matter contained. For domestic use one of its leading features is that it produces practically no soot and it was formerly sold on the market as sootless coal. In this respect it is much superior to the Allegheny coal of the region. Owing to the purity of the coal, it is somewhat tender, and does not withstand ship-

Quakertown must be classed as one of Ohio's very best coals. The low sulphur and ash contents, and the free burning and sootless qualities, combined with high heating value, make it a standard domestic coal seldom surpassed. Owing to the superior quality of the Quakertown coal the competition to dislodge it from the market has been very keen, and reports have been circulated that the field is exhausted, but this statement is far from the fact, since the known unworked areas justify the affirmation that many millions of tons of this valuable fuel are yet available.

KIDNEY ORE

In the region north of Jackson there is found an unsteady deposit of kidney ore, which occurs above the horizon of the Quakertown coal and below that of the Bear Run. It was formerly mined by stripping along the outcrop for smelting in the old charcoal furnace. The bed is best represented in the northern part of Lick and the southern part of Coal townships, although it was found occasionally at other places in the county. The ore is of the limonite type along the outcrop, but where unweathered under heavy cover it is a carbonate. The following section, taken on the property of Mrs. J. G. McKittrick, in Section 17, Lick Township, shows the position of the ore with reference to the Quakertown coal:

	Ft.	In.
Ore, kidney	--	4
Shales, and covered	25	--
Coal, *Quakertown*	2	6

On land of John W. Simpson, in Section 7, Coal Township, the kidney ore, with both the Bear Run and Quakertown coals, was seen. The section taken and given below established its relation with reference to the coals:

	Ft.	In.
Shale, dark, carbonaceous, fissile, *Bear Run* coal horizon	1	--
Sandstone	--	6
Clay shale	2	--
Shale and covered	6	6
Ore, kidney, reported thickness	--	4
Shale, gray, part covered	21	--
Coal, *Quakertown*, reported thickness	2	4

In Section 25, Jackson Township, on land of John Shannon, the kidney ore and the blossom of the Quakertown coal, were exposed along the roadside. The measurements taken follow:

	Ft.	In.
Ore, kidney, sandy	--	3
Shales	20	--
Coal blossom, *Quakertown*	1	--

The bed is too thin and unsteady to be of any considerable value at present, but it had more value during the early days of iron making in Jackson County. At times the stratum is of some aid in tracing the coal horizons found above and below this deposit. No fossils were noticed in the ore, but no particular attention was paid to this feature.

BEAR RUN COAL

The next member in the ascending scale worthy of attention is the Bear Run coal, which is found from 20 to 35 feet above the Quakertown coal, or from 45 to 80 feet above the Sciotoville clay, but the latter interval averages about 60 feet in Jackson County. Although wanting in many localities the bed can be traced with some degree of certainty from Scioto County northward through Jackson into Vinton.

In the area above drainage in this county the Bear Run coal is best developed in local districts in Hamilton, Scioto, and Lick townships, although the member is found also in Jefferson, Franklin, Liberty, Coal, and Washington. In the latter townships the bed is generally thin and often wanting. A marked feature of the member is the variability in character of the materials that make up the deposit. It may be represented by cannel or bituminous coal, black band ore, bone shale, or almost any combination of the above. A fossiliferous zone, which is of some aid in tracing and correlating the member, is found closely associated with the coal. In the Dever Valley *Lingula tighti* occurs in great numbers in the shale that forms the roof of the coal, and northeast of Jackson it is found in the black band ore or bone shales, which are directly related to the coal.

Stratigraphy

On Bear Run, in the northern part of Bloom Township, Scioto County, the Bear Run coal has good thickness, and has been worked for many years. This productive area extends northward into Jackson County, and is of some importance in the Dever Valley, where it furnishes the local fuel supply.

Hamilton Township.—In Section 37, Hamilton Township, the Bear Run coal has been mined on land of S. B. Gilliland, and the Sciotoville clay was seen near the Valley School on the property of Delmer Dever. The section taken is as follows:

		Ft.	in.
Shales, dark blue, lower part fossiliferous		10	--
Coal, *Bear Run*		1	4
Shales, sandstones and covered		78	--
Clay, flint, reported thickness	*Sciotoville*	7	--
Clay, "pink eye"		5	--

When the region was visited the Bear Run coal was being mined on land of E. C. Gilliland, in Section 26, where the following relations were noted:

	Ft.	In.
Ore, *Upper Mercer*, thickness of lumps seen on outcrop	--	4
Covered	15	--

	Ft.	In.
Ore, *Sand Block*, thickness on outcrop	--	3
Covered	126	--
Coal, *Vandusen*, reported thickness	1	3
Shales, and covered	21	--
Coal, *Bear Run*, 1 to 8 inches upper part cannel	2	6

In Section 24, on the land of H. H. Stevenson, the Bear Run coal has been mined by stripping, and just above it the Vandusen coal was worked in a small way by entry. Mr. Samuel Stevenson reports the Bear Run coal to be from 1 foot 6 inches to 1 foot 10 inches in thickness, and the Vandusen to vary from 1 foot 6 inches to 2 feet 2 inches in thickness, and both coals to be of good quality. The Bear Run coal lies just above a sandstone, which in some localities thickens and replaces the coals. This sandstone is highly cross-bedded, and in parts of southern Jackson County changes to a series of thin to medium-bedded flaggy sandstones with shales intervening. Here the two coal beds are quite close together. The section obtained is recorded below:

	Ft.	In.
Shale, gray, sandy	5	--
Shale, dark blue, sandy	1	--
Coal, *Vandusen*	1	8
Clay, siliceous, dark	1	6
Shale and covered	13	--
Shale, dark, fissile	--	6
Coal, *Bear Run*, reported thickness	1	6

The Bear Run coal, with the ores above, were noted on land of Henry Comer in Section 35. The following measurements were recorded:

	Ft.	In.
Coal blossom, *Tionesta* or *No. 3b*	1	--
Covered	25	--
Ore, *Upper Mercer* or *Big Red Block*, thickness from lumps seen	--	6
Covered	17	--
Ore, *Sand Block*	--	3
Covered	45	--
Ore, *Lower Mercer* or *Little Red Block*, lumps seen	--	2
Covered	35	--
Sandstone	5	--
Shale, blue, tough	5	--
Coal, *Bear Run*	1	8

A good exposure of the deposit was obtained on the land of Edward Toppins, in Section 25, where it was being benched near the base of the hill. The section follows:

	Ft.	In.
Coal blossom, *Tionesta*	1	--
Covered	40	--
Ore, *Sand Block*	--	4
Covered	133	--

		Ft.	In.
Shale, blue		10	--
Shale, blue, tough, lower part fossiliferous		2	--
Coal, good	*Bear Run*	1	7
Coal, bony		--	3
Shale, black, carbonaceous		--	6

Near the head of the Dever Valley, in Section 24, the Maxville limestone is found in the bed of the stream on the land of Amos Canter, and about 20 feet above this on the Joseph Woods property the Bear Run coal has been mined. A section from the limestone to the summit of the hill to the east is given below:

		Ft.	In.
Ore, *Upper Mercer* or *Big Red Block*		--	4
Covered		13	--
Ore, *Sand Block*, very fossiliferous		--	4
Covered		27	--
Ore, small kidneys, *Lower Mercer* or *Little Red Block*		--	1
Clay, light		1	--
Shales with parts covered		12	--
Sandstone		1	--
Shales, sandy		7	--
Sandstone, light, fissile		1	--
Shales, dark, tough, part fissile		3	6
Sandstone, light, soft		3	4
Sandstone, dark, soft		1	--
Coal blossom, *Lower Mercer*		--	8
Clay, plastic, dark		1	6
Shales and thin bedded nodular sandstones		5	--
Shales and covered		10	--
Irregular band of iron carbonate nodules		--	6
Shales		6	6
Shales, sandy		17	--
Shales, dark, very carbonaceous, *Vandusen* coal horizon		--	6
Shales, sandy		13	6
Shales, dark, tough		3	--
Coal, *Bear Run*, 3 to 4 inches cannel coal reported in upper part		1	1
Shales and covered		14	6
Sandstone, shaly		3	--
Sandstone, irregular, ferruginous		1	--
Clay shales, light greenish		3	--
Limestone with flint and iron ore, *Harrison*		1	--
Limestone, gray	*Maxville*	1	6
Limestone, reported below		7	6

Along the Little Scioto River, north of the Dever Valley, the horizon of the Bear Run coal is made up of thin and medium-bedded flaggy sandstones. The coal was not found exposed at any point. This was the case also on Bucklick and Little Bucklick creeks.

Scioto Township.—On Sugarcamp Creek the Bear Run coal thickens again, and has been worked at a few places. Near Grahamsville, in sections 26 and 27, Scioto Township, the thin blossom of the

Bear Run coal, the Sciotoville clay, Jackson Sand Block ore, and Vandusen coal are exposed. The section is as follows:

		Ft.	In.
Ore, kidney		--	4
Shales, part sandy		27	--
Ore, kidney		--	3
Shales, sandy		7	9
Covered		6	--
Shales		2	--
Coal, *Vandusen*		--	6
Sandstone, argillaceous		3	--
Sandstone, light		3	6
Ore, sandy	*Jackson Sand Block*	1	2
Shales		1	5
Ore, sandy		--	6
Sandstones, flaggy		6	--
Shales		26	--
Coal blossom, *Bear Run*		--	4
Clay, plastic, dark		1	6
Shales		6	--
Sandstone, plant marked, ferruginous		1	--
Shales		16	--
Flaggy sandstone, shales and covered		13	--
Coal and bone shales		2	--
Clay, light, sandy		1	6
Shales		1	--
Thin sandstones and shales		2	--
Sandstone, ferruginous		--	7
Shales, blue		--	5
Coal, *Anthony*		--	1
Clay, light, plastic, with some "pink eye"	*Sciotoville*	4	4
Clay shales, dark		3	8
Clay shales and covered		5	--
Coal		--	1
Clay, flint, sandy		1	6
Covered		20	--
Conglomerate, *Sharon*		10	--

In Section 26, on land of Jehiel Haley, the Anthony coal was found in digging a well, and on the hill north of this the Vandusen coal has been opened. To the west of this the Bear Run coal has been mined on land of A. A. Rehs. The Bear Run coal has also been mined on the property of John Miller, in Section 22. South of the Fairview School, in Section 23, the interval from the Bear Run to the Vandusen coal is short.

In Section 11, on the isolated hill west of the Portsmouth-Jackson road, the Bear Run coal has been mined on land of Oliver M. Mercer, and the Jackson Sand Block ore on that of Garrett Brothers. The ore and coal openings are some distance apart, so the section following is not very accurate:

	Ft.	In.
Ore, seen, *Jackson Sand Block*, sandy	4	--
Sandstone	8	--

	Ft.	In.
Shale, dark	2	--
Coal, *Bear Run*, reported thickness	2	--
Covered	80	--
Sandstone, shaly	8	--
Covered	5	--
Conglomerate, *Sharon*	6	--

East of the above several mines have been worked on land of William Martin, where the Bear Run coal is reported 1 foot 10 inches thick.

Near the residence of J. M. Broyles, in the western part of Section 12, this coal has also been mined for local use. The Bear Run coal goes under cover along Buckeye Creek on the land of William T. Inman, where it has been stripped in the creek bed. The interval to the Little Red Block ore, or Lower Mercer horizon, is as given below:

	Ft.	In.
Ore, *Lower Mercer* or *Little Red Block*, fossiliferous	--	4
Covered	88	--
Coal, *Bear Run*, reported thickness	1	10

On the branch of Salt Creek that heads south of the furnace of the Jackson Iron & Steel Company, the Bear Run coal is represented by dark carbonaceous shales, with occasional pockets of thin coal. Near the head of the stream, on land of J. M. Johnson, Section 12, Scioto Township, these dark shales, with thin coal bands, are well exposed in the creek bed, and the Lower Mercer ore is found on the hill to the west. A composite section taken here is as follows:

	Ft.	In.
Ore, *Lower Mercer*, very fossiliferous, may be derived from weathering of Lower Mercer limestone	--	5
Covered	34	--
Clay and sandstone, light	4	--
Covered	3	--
Shales, gray	10	--
Shales, sandy	6	--
Covered	5	--
Shales	2	--
Coal blossom	1	--
Clay, sandy	2	--
Shales, gray, sandy	3	--
Shales, dark, tough	1	--
Shales, blue	7	--
Covered	27	--
Sandstone, flaggy	5	--
Shales, dark, carbonaceous, with thin coal bands, *Bear Run* coal horizon	3	--

Farther down the stream, in Section 1, on land of T. A. Henderson, a composite section is as given below:

	Ft.	In.
Ore, *Lower Mercer*, fossiliferous	--	6
Covered	86	--

	Ft.	In.
Ore, *Jackson Sand Block*, reported thickness	1	--
Covered	8	--
Carbonaceous shales with thin coal bands, *Bear Run* coal horizon, reported thickness	2	4
Shale	8	--
Sandstone, flaggy	24	--
Covered	5	--
Coal, cannel nature, *Quakertown*, reported thickness	--	6

Lick Township.—South of Jackson, in Lick Township, the Bear Run coal horizon is well marked, but it carries coal of good quality at only a few places. In Section 31, on land of H. Hunsinger, the carbonaceous shale on the horizon was exposed as follows:

	Ft.	In.
Ore, *Jackson Sand Block*, reported thickness	2	--
Covered	23	--
Bone shales, *Bear Run* coal horizon	2	--
Covered	30	--
Coal, cannel nature, *Quakertown*, reported thickness	--	4

In the eastern part of Section 31, on the land of J. J. McClung, the coal has been mined in a small way where it is 2 feet thick. The maximum thickness of the coal in this locality, reported by Dr. McClung, is as follows:

	Ft.	In.
Coal, good quality	1	8
Shale, black, hard	--	2
Coal, dense, high ash	2	6

The Bear Run coal has been prospected at several places south of the deposit on J. J. McClung's land, but the bed is represented mainly by black carbonaceous shales. A composite section on lands of F. H. and James Mayhew is as given below:

		Ft.	In.
Ore, *Lower Mercer*.			
Covered		13	--
Shales, gray		8	--
Shales, blue, tough		6	--
Coal		--	1
Shales, gray, sandy		7	--
Coal, part cannel, *Lower Mercer*		1	6
Clay shales		2	6
Shales		13	--
Sandstone		24	--
Shales, sandy		3	--
Coal, bright	*Vandusen*	--	11
Clay shales		--	3
Coal		--	1
Clay shales, blue, sandy		1	6
Shales, sandy		5	--
Covered		19	--

About place of *Bear Run* coal seen across hollow.

East of Jackson, in Lick Township, the Bear Run coal thickens, and has been opened at a number of places. In Section 21, on land of D. D. Evans, an entry was driven some distance into the hill to determine the character of this coal. The structure of the deposit reported by Mr. Evans is as follows:

		Ft.	In.
Shale		35	--
Coal, part cannel	*Bear Run*	1	8
Bone shale, tough, fissile		--	8
Ore, black band		--	10
Bone shale, tough, fissile		--	4

Southwest of the above, on the property of Reuben W. Swift, the section obtained in a mine is as given below:

		Ft.	In.
Ore, *Lower Mercer*		--	4
Covered		74	--
Shale		4	--
Coal, cannel, good	*Bear Run*	--	6
Coal, cannel nature		1	5
Bone shale, fissile		--	4
Shale, black, carbonaceous		1	--

In the same section, north of the Baltimore & Ohio Southwestern Railroad, on the property of Simon L. David, both the Bear Run and Quakertown coals were exposed on the outcrop. The section measured follows:

		Ft.	In.
Ore, black band, with thin coal bands	*Bear Run*	--	6
Coal, bituminous		--	7
Bone shale		1	--
Shale		1	--
Sandstone		3	--
Covered		11	--
Sandstone, shaly		5	--
Coal, weathered, *Quakertown*		1	--

Near the Crescent mine, in Section 16, the Bear Run coal is exposed, and the section showing the interval is as given below:

		Ft.	In.
Ore, black band, fossiliferous	*Bear Run*	--	4
Coal, bituminous		--	8
Bone shale		--	6
Shales with parts covered		23	8
Coal, part bony, *Quakertown*		2	6

The Bear Run coal was exposed along the stream north of Young America Furnace. A composite section east of the residence of Mrs. J. Butts shows the following members:

		Ft.	In.
Ore, horizon, *Lower Mercer*.			
Covered		13	--
Limestone	*Lower Mercer*	--	10
Shale		2	2
Limestone		1	--

		Ft.	In.
Covered		37	--
Coal blossom		1	--
Clay shale		4	--
Sandstone and covered		11	--
Sandy shale with thin sandstone		7	--
Shale, dark		4	--
Coal, cannel nature	*Bear Run*	--	9
Shale		--	2
Coal, cannel		--	2
Ore, black band, fossiliferous		--	3
Coal, bituminous		--	4
Sandstone		4	--
Shale		10	--
Coal blossom		--	3
Shale, blue, sandy		3	9
Shaly sandstone, plant marked		1	3
Shale, sandy, with carbonate ore nodules		5	10
Coal, bony	*Quakertown*	--	4
Coal, good		--	9
Clay, bluish, sandy		1	6
Ore, irregular kidneys		--	5

In Section 8, on land of M. H. Harrison, the Bear Run coal has been opened. The deposit is reported to be about 2 feet in thickness, and the coal to be of the cannel type. The section taken follows:

	Ft.	In.
Coal, *Bear Run*, cannel nature, reported thickness	2	--
Covered	18	9
Shale, blue	4	--
Ore, kidney	--	3
Shale, blue	6	--
Coal, *Quakertown*	3	--

Coal and Washington Townships.—In northern Coal and in Washington townships the Bear Run coal is largely replaced by the heavy sandstones found above the Quakertown bed. In the creek bed, in the hollow north of the No. 3 mine of the Superior Colliery Company, Section 23, Washington Township, irregular lenses and bands of coal were seen in the sandstone. The coal lies just above the line of disconformity between the sandstone and the shale below, and evidently represents the Bear Run coal in a broken and unsteady condition. The irregular lenses are about 40 feet above the Quakertown coal. North of this, the coal, in much the same condition, was noticed at several places, but in a few localities it is regularly bedded. In Section 10, on land of W. W. Manning, the following record was obtained, which shows the position of the Bear Run coal with reference to the Quakertown and Lower Mercer:

Ore, *Lower Mercer*.	Ft.	In.
Shale and covered	27	--
Coal, *Lower Mercer*	2	4
Sandstone	15	--

		Ft.	In.
Covered		23	--
Coal, *Bear Run*, reported thickness		1	--
Sandstone and covered		36	--
Coal	*Quakertown*, reported thickness	1	8
Clay shale		--	4
Coal		--	6

The blossom of the Bear Run coal, about 1 foot in thickness, was noticed at other places in this locality.

Extent

The extent above drainage of the Bear Run coal, where of sufficient thickness for mining at present, even in a small way, is confined to a few areas more or less restricted. The most southern field of Bear Run coal in Jackson County is found in the Dever Valley in Hamilton Township. The best of this field extends eastward from near the Valley School to where it goes under cover near the Hamilton-Jefferson line. The thickness varies from 1 foot to 2 feet 6 inches, with an average of nearly 1 foot 10 inches. South along Tattle Creek it is thin or wanting, since often the deposit is replaced by massive sandstones. Along the Little Scioto River north of the Dever Valley this coal is also thin or wanting. It is not known whether the coal extends eastward under heavy cover as no drilling has been done in the region. The next area noted where the Bear Run coal has any considerable thickness is in sections 22 and 23, Scioto Township. The thickness in this small field is from 1 foot 6 inches to 2 feet. This area apparently extends northward across the main ridge to the head of Buckeye Creek in sections 11 and 12, where the thickness of four exposures measures from 1 foot 8 inches to 2 feet. In the valley of the small stream south of the furnace of the Jackson Iron & Steel Company the deposit is represented by carbonaceous shales with thin coal bands, and is of no importance. In the eastern part of Section 31, Lick Township, there is a small area in which some good coal has been obtained. South and east of this, where exposed, it is thin or bony. Another area is along the Baltimore & Ohio Southwestern Railroad from near Jackson to Young America Furnace. In this area the thickness and structure of the bed, and the character and quality of the coal, are quite variable. Three openings showed a thickness of 1 foot 10 inches of good coal. The area extends northward into Coal Township, but is quite restricted, for in northern Coal and Washington townships the bed is largely replaced by massive sandstones.

Economic Value

The Bear Run coal, in the Dever Valley, has been worked in a small way for many years, and is mined at present for a part of the local fuel supply. Although the deposit is thin, the coal is of excellent quality, and the mining conditions good, as the roof is a tough shale and the floor a sandy clay. The stratum consists mainly of only one bench, in the upper part of which is found from 1 to 8 inches of cannel coal. The mining has been confined to coal along the outcrop, or reached by short entries, so the supply for local consumption yet available will last for years.

The next field, extending from the head of Sugarcamp Creek to that of Buckeye Creek, has been worked at a few places where the coal has a thickness of about 2 feet. The structure of the bed is much the same as that in the Dever Valley, part tending towards the cannel type, and the quality of the coal is excellent for domestic use, as it belongs to the high volatile free-burning class. The area of the workable field south of Jackson, from the indications of the exposures noted, is very small. The coal has good volume on lands of McClung and Farrar, where it has been mined by entries. The available supply is largely exhausted.

The Bear Run coal in the field along the Baltimore & Ohio Southwestern Railroad, northeast of Jackson, has been opened or worked at only a few places, as the deposit is thin and variable, and as the Quakertown coal adjacent to the region is easily obtained at present. The deposit is made up of cannel coal, bituminous coal, bone shale, and black band ore, or some combination of the above. The thickness of the strata and the order of sequence changes from place to place, thus making the mining somewhat difficult and uncertain.. The maximum thickness of good coal measured, part of which is cannel or of a cannel nature, was about 2 feet. The tough shale or sandstone forming the roof, and the carbonaceous shale, clay shale, or sandstone forming the floor of the stratum, are thus of such character as to give safety and yield in mining. The associated black band ore is sufficiently rich in iron to be of value to the local furnaces for metallurgical use. Tests, which are reported satisfactory, have been made of the bone shales for their utilization as pigments for mineral paints.

The quality of the Bear Run coal in the Dever Valley field is excellent. It is free-burning, low in sulphur and ash, and has good heating qualities. The character of the coal is shown by an analysis of a sample from land of Enoch Canter, Section 24, Hamilton Township, which is as follows:[1]

Specific gravity	1.298
Combined water	8.55
Ash, white	5.20
Volatile matter	25.25
Fixed carbon	61.00
Total	100.00
Sulphur	0.58

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[1] Geol. Surv. of Ohio. Rep. for 1870, p. 157.

The analysis of a sample from near Jackson Furnace, Section 34, shows the following composition:[1]

Specific gravity	1.296
Combined water	5.30
Ash	3.10
Volatile matter	32.60
Fixed carbon	59.00
Total	100.00
Sulphur	0.78
Ash, yellow.	

The Gilliland coal of southern Hamilton Township, as sampled by Mr. C. N. Brown, and analyzed by Professor Lord, shows the following constitution:[2]

Moisture	7.04
Volatile matter	37.89
Fixed carbon	44.09
Ash	10.98
Total	100.00
Sulphur	1.19

On the land of Mr. Price, Section 18, Lick Township, the Bear Run coal lies 32 feet above the Quakertown, and is a cannel. The analysis of a sample of it is as follows:[3]

Specific gravity	1.415
Combined water	2.25
Ash	23.00
Volatile matter	34.75
Fixed carbon	40.00
Total	100.00
Sulphur	0.84
Cubic feet permanent gas per pound	2.19

At present the Bear Run coal is of some value locally for small domestic supplies, but in the future, as the thicker coals reach exhaustion, this, with other thin beds, will become of more importance.

JACKSON SAND BLOCK ORE

The productive field of the Jackson Sand Block ore is southwest of the town of Jackson, and includes the southwestern part of Lick, the southeastern part of Liberty, and the northeastern part of Scioto townships. The deposits, although somewhat isolated and irregular in structure, occur in the same general interval which is that between the Bear Run and Vandusen coals.

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[1] Geol. Surv. Ohio, Report of Progress, 1870, p. 158.

[2] Geol. Surv. Ohio, Vol. V, page 1011.

[3] Geol. Surv. Ohio, Report of Progress, 1870, p. 145.

Shales, thin to medium-bedded sandstones, with shales intervening, massive sandstones, or some combination of the above strata, make up the interval which is from 20 to 40 feet in thickness. Layers of the thin and medium-bedded sandstones, which have been enriched by iron compounds, constitute the ore beds. These deposits may occur interbedded in shales, or at the top or well down in the series of sandstones, but the richest beds are those in the shales, or in the upper part of the sandstone series. The position at which they occur in the interval varies from place to place; thus beds worked in one locality may not be on the same level stratigraphically as those worked at another.

Under heavy cover the iron is in the form of the carbonate, while along the outcrop, or under shallow cover, where the weathering agents have been active, it occurs in the hydrated oxide forms. The sandstone strata are fine-grained, ripple marked, more or less ferruginous, and contain plant fossils. Apparently the iron compounds were deposited with the sands in shallow basins in which the waters were charged with iron salts and decaying organic matter. The deposits, as a usual thing, have a higher iron content along the outcrop, or under shallow cover, where local enrichment from percolating water has taken place.

Stratigraphy

The Jackson Sand Block ore has been mined on the land of Martin Wastier, in Section 26, Scioto Township. The following section shows the strata exposed for measurement:

		Ft.	In.
Ore, kidney		--	4
Shales, part sandy		27	--
Ore, kidney		--	3
Shales, sandy		7	9
Covered		6	--
Shales		2	--
Coal, *Vandusen*		--	6
Sandstone, argillaceous		3	--
Sandstone, light		3	6
Ore, sandy	*Jackson Sand Block*	1	2
Shales		1	5
Ore, sandy		--	6

Just north of this, in the same section, on the property of J. M. Pierce, the ore has also been mined, and is reported to be from 3 to 4 feet in thickness. A small pocket of ore has been mined near the summit of the hill on land of James I. Garrett, in Section 9. The record follows:

	Ft.	In.
Ore, *Jackson Sand Block*, approximate thickness	2	6
Sandstone, thin to massive bedded	20	--

	Ft.	In.
Covered	80	--
Conglomerate, *Sharon*	40	--

The deposit of Jackson Sand Block ore on the property of John M. Corn, in Section 2, was being worked when the region was visited. The ore layers, which are quite variable in thickness and number, are interbedded in shales. A section of the mine is as follows:

		Ft.	In.
Shale		6	--
Ore	*Jackson Sand Block*	1	2
Shale		--	11
Ore, solid block		5	10

Another section in the same mine, about 100 feet from the above, shows the variability of the deposit, hence the measurements are given below:

	Ft.	In.
Shale.		
Ore	--	6
Shale	1	--
Ore	--	8
Shale	1	8
Ore	--	6
Shale	2	10
Ore	5	4

In Section 3, on Thomas Wade's land, the ore measured 2 feet in thickness. On land of T. A. Henderson, in Section 1, the ore was mined in a small way, and is reported to be 1 foot thick.

In Liberty Township, just north of the Corn mine, on land of Howell and Jones, Section 34, the Jackson Sand Block ore is interbedded in sandstones. A section shows the following relations:

		Ft.	In.
Ore, seen, *Jackson Sand Block*		1	--
Covered		71	--
Sandstone, massive		12	--
Covered		18	--
Sandstone, massive		12	--
Disconformity.			
Ore nodules and finger coal in sandstone		1	--
Sandy shale		--	10
Coal	*Sharon* coal horizon	--	2
Shale, dark, carbonaceous		--	6

Near the summit of the hill just south of the old Hammertown mine, in Section 35, the ore has been dug along the outcrop quite extensively. A section is as follows:

	Ft.	In.
Ore, *Jackson Sand Block*, reported thickness	2	--
Sandstones, thin to massive bedded	20	--
Covered	110	--
Coal, *Sharon*	2	6

In the southeastern part of Section 35, on the Johnson farm, the ore has been mined in a small way for years. A measurement showed 2 feet 2 inches of ore, but elsewhere, under heavy cover, the ore is reported to be 6 feet thick. This ore has been mined along the outcrop at a few places in Section 25. The rocks seen on the Elisha Scurlock property are as follows:

	Ft.	In.
Ore, *Jackson Sand Block*	2	--
Shale, sandy	11	--
Sandstone, thin to medium bedded	10	--
Covered	45	--
Shale	5	--
Sandstone, thin to medium bedded	10	--
Covered	6	--
Shale	8	--
Covered	22	--
Coal, *Sharon.*		

In several localities in the southwestern part of Lick Township the ore has been mined also in a small way. On lands of the Jackson Iron & Steel Company and Charles Ray, in Section 30, the following members were noted:

	Ft.	In.
Ore, *Jackson Sand Block*, thickness reported	2	--
Shales, sandy	10	--
Sandstone and covered	36	--
Covered	4	6
Coal, cannel, *Quakertown*	--	6
Clay and covered	2	--
Top of air shaft.		
Covered and shales	59	6
Coal, *Sharon*, reported thickness	3	6

Economic Value

The Jackson Sand Block ore, as the name implies, is a sandy or siliceous ore with a blocky structure, as the beds are regularly jointed. The iron content varies from the lowest limit used for ores to about 45 per cent, but in the bulk of the ore mined it is from 30 to 35 per cent. The lime and magnesia, often amounting to several per cent, give an additional value, as they flux directly part of the siliceous gangue of the ore, and as they tend to promote ease of fusion of the silicate impurities. The phosphorus, usually high, and the manganese about normal, make the ore a desirable constituent in the smelting of foundry iron. An analysis of the ore furnished by the Jackson Iron & Steel Company is as follows:

Iron, Fe	30.66
Silica, SiO_2	26.08
Alumina, Al_2O_3	7.56
Phosphorus, P	7.87

Manganese, Mn	.51
Lime, CaO	5.16
Magnesia, MgO	trace
Moisture	6.00

The analyses of the Jackson Sand Block ore given below were furnished by Mr. H. L. Clay, superintendent of the Star Furnace Company:

		No. 1				No. 2		
Iron	From	25.00	to	35.70	From	23.00	to	35.50
Silica	"	21.85	"	28.50	"	24.35	"	33.00
Alumina	"	7.50	"	8.44	"	7.05	"	-- --
Phosphorus	"	.614	"	.875	"	.88	"	1.09
Manganese	"	.49	"	.61	"	.64	"	-- --
Lime	"	2.80	"	5.45	"	.96	"	2.30
Magnesia	"	.67	"	.76	"	.43	"	.94
Sulphur	"	.028	"	.182	"	.17	"	-- --

No. 1. Ore from Corn mine.
No. 2. Ore from Hunsinger mine.

The ore varies from 1 to as much as 8 feet in thickness, but usually averages from 2 to 3 feet. In some localities the ore is interbedded in sandstone, while at other places in shale. So far most of the ore has been mined by stripping along the outcrop where the overburden is not heavy, but the general conditions for drift mining are favorable. Also the demand by the furnaces for outcrop ore has been greater as the iron is in the form of the oxide, and the metal content usually higher. There are large quantities of this ore yet available, but the cost of mining and the low market value, when compared to the siliceous Lake ores on a unit basis, have seriously impeded its utilization at present.

The gangue is in such form that but little enrichment of the ore is possible by any of the common forms of concentration now in use. Washing and careful selection would free the ore from some deleterious clay and shale materials which are derived from the roof and floor, and mechanically mixed during the mining operation. Cleaner ores would increase both the market and market value. One objection in general advanced by furnace people to the use of native ores is that the foreign material in them is usually considerable, and also variable in amount.

VANDUSEN COAL

The Vandusen coal, where present in the southern part of Jackson County, lies from 15 to 30 feet above the Bear Run coal, and from 70 to 100 feet below the Little Red Block or Lower Mercer ore, but in the central part of the county the latter interval thins, measuring usually from 60 to 70 feet. In the northern part of the county the member is usually wanting, but, when present, it is represented only by a few inches of impure coal, or a foot or so of carbonaceous shale. The Vandusen coal in Jackson County is best represented in Hamilton, Scioto, and Franklin townships, where the average thickness of the bed is about 1 foot. It is found also, but in a thin and unsteady condition, in Jefferson, Lick, Liberty, Coal, and Washington townships. The deposit, where present, is usually very thin, seldom exceeding one foot, but the coal is of fine quality, and on this account it is mined by benching along the outcrop, and in the beds of streams where the cover is shallow. At but one place, and that was on land of H. H. Stevenson, in the Dever Valley, was the bed found of sufficient thickness to warrant mining by drifting at present, but in the future this may be done. General sections showing the structure of the deposit and its relation to other members will now be given.

Hamilton Township.—The relation of the Vandusen to the Bear Run coal is shown in the following section, taken on land of H. H. Stevenson, Section 24, Hamilton Township.

	Ft.	In.
Coal, *Vandusen*	1	8
Clay, dark, siliceous	1	6
Shale and covered	13	--
Shale, dark, fissile	--	6
Coal, *Bear Run*, reported thickness	1	6

Here the Vandusen coal has been mined to some extent by entry for local use. Samuel Stevenson reports the thickness of the bed in the mine to vary from 1 foot 6 inches to 2 feet 2 inches. The coal is of excellent quality and the roof very good. On land of E. C. Gilliland, Section 26, Hamilton Township, the Vandusen coal has been opened but not worked. A section taken at this place shows the following relations:

	Ft.	In.
Ore, *Upper Mercer* or *Big Red Block*	--	4
Covered	15	--
Ore, *Sand Block*	--	3
Covered	126	--
Coal, *Vandusen*, reported thickness	1	3
Shales and covered	21	--
Coal, *Bear Run*	2	6

The rocks exposed on the lands of Vinton McCoy and Wm. H. Gahm, Section 11, show the relation of the Vandusen coal to the Lower Mercer and Anthony members. The record follows:

	Ft.	In.
Coal, *Lower Mercer*, reported thickness	2	6
Sandstone, massive	21	--
Shales	9	--
Coal, *Vandusen*	1	--
Clay and shales	5	--
Sandstone with parts covered	40	--
Sandstone, shaly, blue, with shales intervening	20	--
Shales, blue	10	--
Coal, *Anthony*, reported thickness	1	2

In the eastern part of Section 1, on the property of Marion Vandusen, the structure of the bed where stripped is as shown below:

	Ft.	In.
Ore, *Upper Mercer*	--	6
Covered	37	--
Ore, *Lower Mercer* or *Little Red Block*	--	3
Covered	77	--
Shale, dark blue	7	--
Shale, light blue, with many plant fossils well preserved	2	--
Bone shale } *Vandusen*	--	6
Coal, good } *Vandusen*	--	11

The Vandusen coal was found also along the head of Bucklick Creek and in Pigeonroost Hollow.

Franklin Township.—In Franklin Township, along the headwaters of Fourmile Creek, the Vandusen member has been stripped at many places for domestic fuel. A section taken along the road from Fourmile Creek to the ridge in Section 30 shows the following relations:

	Ft.	In.
Ore, *Upper Mercer*	--	8
Shale and covered	37	--
Sandstone, massive	16	--
Shale and covered	30	--
Dark carbonaceous shale, *Lower Mercer* coal horizon	3	--
Covered	19	--
Shale and covered	20	--
Shale, tough, fissile	--	6
Shale	5	6
Coal blossom, *Vandusen*	--	6

The following section, showing the relation of the Vandusen coal to other members, was obtained on land of B. E. Lyons, in Section 18, Franklin Township:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Shales and covered	56	--
Coal and covered, *Lower Mercer*	3	--
Covered	23	--
Shales	15	--
Limestone, bastard, nodular, blue	1	--
Shales	7	--
Coal, *Vandusen*	--	10
Clay, light, plastic	1	--

In Section 20, on the land of David Simmons, the Vandusen coal was exposed in the bed of the stream, and to the west on property of Henry Hughes a cannel coal on the Lower Mercer horizon was seen. The following composite section was measured on lands of D. C. Colby and George Rehs, in sections 7 and 8, Franklin Township:

	Ft.	In.
Ore, *Upper Mercer*	--	8
Covered	18	--

	Ft.	In.
Ore, sandy, *Sand Block*	--	3
Covered	40	--
Shales	7	--
Coal	--	8
Covered	60	--
Shales	6	--
Coal, *Vandusen*, good	--	8
Clay, siliceous, blue	1	6

On land of James Mayhew, in Section 5, the following rocks were exposed:

		Ft.	In.
Ore, *Lower Mercer*.			
Covered		13	--
Shales, gray		8	--
Shales, blue, tough		6	--
Coal		--	1
Shales, gray, sandy		7	--
Coal, *Lower Mercer*, part cannel		1	6
Clay shales		2	6
Shales and covered		13	--
Sandstone		24	--
Shales, sandy		3	--
Coal, bright	*Vandusen*	--	11
Clay shales		--	3
Coal		--	1

Scioto Township.—Along the stream east of Fairview School, in Section 13, Scioto Township, the Vandusen coal has been benched in several places. A composite section on W. T. Plummer's and H. A. Wykle's land is as follows:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Covered	43	--
Sandstone and covered	20	--
Covered	14	--
Coal and bone shales, *Lower Mercer* coal horizon	4	--
Covered	9	--
Shales, gray	11	--
Shales, blue, many plant fossils	7	--
Coal, *Vandusen*	--	11

Other Townships.—Northward from Jackson in Lick, Coal, and Washington townships, the Vandusen coal is scarcely represented. In most of the area the interval is made up of heavy sandstones which replace the bed, but even where shales predominate the horizon is seldom marked by more than a stain of coal, with a thin, siliceous clay below. The field of the Vandusen coal is from Jackson south to the Dever Valley, and from this point it extends on into Scioto County. It is best represented in Franklin, Scioto, and Hamilton townships.

Economic Value

The Vandusen coal is of but little importance at present, as a source of fuel supply for the bed is thin, seldom exceeding one foot in thickness, but the coal is of excellent quality. .It is a bright, dense, bituminous coal, very free from shaly bands and sulphur nodules. It is an oily coal, tending somewhat towards the cannel types, and burns with a free open flame. The dense nature of the coal, with that of the shales above, protects it from the weathering agencies, so the stratum is found in good condition where only a few feet of cover exists. On this account it is benched along the outcrop and in the beds of streams.

Along the headwaters of Little Scioto River north of Mabee, and along those of Fourmile Creek, where the bed is best developed, it furnishes a part of the local fuel supply. The deposit, where one foot thick, will produce about 750 pounds coal per square yard of surface. The roof of the coal in most places is a heavy deposit of shale, well suited for ceramic purposes, but the floor is either a sandstone or a siliceous clay having no special value. The bed is too thin to be mined alone successfully by drifting, and the associated materials are not of enough value to warrant this method. The main value of the Vandusen coal lies in the fact that it may furnish a small local supply of good fuel in a region where the other coals are also thin or bony.

LOWER MERCER COAL

The Lower Mercer coal, in only a few localities in Jackson County, is of sufficient thickness and purity for utilization, as the member is more often wanting, or represented by a series of carbonaceous shales with thin coal bands. The position of the Lower Mercer coal in the southern part of the county is from 35 to 55 feet, with an average of 45 feet below the Lower Mercer or Little Red Block ore. In the northern part of the county, where the Lower Mercer limestone is also present, the coal is separated from the limestone by an interval of about 25 feet. It lies directly or only a few feet below the Boggs ore, but the latter is seldom found in Jackson County.

On the Lower Mercer coal horizon there are several coal strata that are closely related, for they were laid down during a continuous but more or less interrupted swamp period, in which a very irregular series of thin coals, highly carbonaceous shales, carbonate ores, and siliceous clays, inter-stratified with thin shales and sandstones, were deposited over a wide area. A coal stratum observed on this horizon in one locality may not be the same as that found on the horizon in another place only a few miles distant, but both coals belong to the same general deposition period. In fact, several coal beds occur in this interval which is only a few feet in thickness.

The Lower Mercer coal extends from the Ohio River across eastern Scioto and western Lawrence counties, and then across central Jackson

County to central Vinton. It was not traced farther north. In Jackson County the Lower Mercer coal is found in parts of Hamilton, Scioto, Franklin, Lick, Coal, Milton, and Washington townships, but it is best represented, however, in parts of Hamilton, Scioto, and Washington townships. The member will be traced in a general way across this area.

Stratigraphy and Extent

Hamilton Township.—The Lower Mercer coal extends across Hamilton Township, where it has been prospected at several places. This coal bed is shown in the following section, taken on the Joseph Wood property, in Section 24:

	Ft.	In.
Ore, *Upper Mercer* or *Big Red Block*	--	4
Covered	13	--
Ore, *Sand Block*, fossiliferous	--	4
Covered	27	--
Ore, *Lower Mercer* or *Little Red Block*	--	1
Clay, light	1	--
Shales with parts covered	12	--
Sandstone	1	--
Shales, sandy	7	--
Sandstone, light	1	--
Shales, dark, tough, part fissile	3	6
Sandstone, argillaceous, soft, light	3	4
Sandstone, shaly, dark	1	--
Coal blossom, *Lower Mercer*	--	8
Clay, dark, plastic	1	--

North of this, on the same property, Mr. Wood reports the coal, where prospected, to be 2 feet in thickness. When visited (1913) the Lower Mercer coal was being mined on land of Roy Shumate in Section 2. The structure found is as given below:

		Ft.	In.
Shale, blue		2	--
Shale, carbonaceous, with thin coal bands	*Lower Mercer*	--	5
Clay shale, dark		--	3
Coal, good		1	5
Clay		--	5
Sandstone		17	--
Sandstone and covered		6	--
Shale		4	--
Coal, *Vandusen*		1	--

Scioto Township.—In Section 13, Scioto Township, on land of W. T. Plummer, the following section was measured:

	Ft.	In.
Coal and bone shales, *Lower Mercer*	4	--
Covered	9	--
Shales, gray	11	--
Shales, dark blue, part sandy	7	--
Coal, *Vandusen*	--	11
Clay, shaly	1	10

Franklin Township.—The Lower Mercer coal has been opened on land of Henry Hughes, in Section 20. In the northwest corner of Section 21, on land of G. W. Masters, the section obtained is as given below:

	Ft.	In.
Ore, *Upper Mercer*	--	3
Covered	47	--
Sandstone, massive	30	--
Shale and covered	15	--
Coal, part cannel, *Lower Mercer*	--	6

On land of John Sheward, in the same section, the coal has been mined for domestic use. This coal is also represented on the property of Conrad Sheward, Section 16, where the following record was taken:

		Ft.	In.
Ore, *Upper Mercer* or *Big Red Block*		--	4
Shales and covered		13	--
Ore, *Sand Block*		--	4
Covered		23	--
Sandstone, massive		22	--
Covered		8	--
Sandstone		8	--
Covered		11	6
Coal, cannel	*Lower Mercer*	--	10
Shales, dark, carbonaceous, thin coal bands		1	--
Clay shales		1	--

The relation of the Lower Mercer coal to the ore and Vandusen coal is shown in the following section, measured on land of James Mayhew, in Section 5:

		Ft.	In.
Ore, *Lower Mercer.*			
Covered		13	--
Shale, gray		8	--
Shale, blue, tough		6	--
Coal		--	1
Shale, gray, sandy		7	--
Coal, *Lower Mercer*, part cannel		1	6
Clay shale		2	6
Shale and covered		13	--
Sandstone		24	--
Shale, sandy		3	--
Coal, bright	*Vandusen*	--	11
Clay shale		--	3
Coal		--	1
Clay shale, blue, sandy		1	6

South of the standpipe, on the property of Peter Radcliff, in Section 3, Franklin Township, the rocks measured are as given below:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Covered	28	4

	Ft.	In.
Shale	3	--
Limestone, *Lower Mercer*	--	8
Clay, shale, light	1	--
Shale with parts covered	22	--
Shale	10	--
Coal, cannel, *Lower Mercer*	1	--

Lick Township.—In Section 34, Lick Township, on land of W. L. Brown, the coal was exposed, while on the ridge south, in sections 2 and 3, Franklin Township, the ores and Ferriferous limestone are present. The measurements recorded are as follows:

Limestone, *Ferriferous*.		Ft.	In.
Covered		42	--
Ore, *Black Flint* horizon		--	4
Covered		43	--
Ore, *Upper Mercer*		--	3
Covered		78	--
Coal, tough, cannel	*Lower Mercer*	--	8
Shale		--	6
Coal, bony, cannel		--	10

North of the Globe mine, on land of E. L. Long, the Lower Mercer coal and the Black Flint ore, which has been worked near the summit of the hill, are found. The section taken is as given below:

Ore, *Black Flint* horizon.	Ft.	In.
Covered	87	--
Shale and covered	30	--
Shale	--	3
Coal, cannel, *Lower Mercer*	1	--
Covered	34	--
Top of air shaft, Globe mine.		
Interval in shaft	110	--
Coal, *Sharon*	3	8

A composite section taken on the property of Michael Radcliff, in Section 23, shows the relations of several members. The thickness of the coals was reported by Mr. Radcliff. The section follows:

Limestone, *Ferriferous*, weathered bowlders on hill.	Ft.	In.
Covered	26	--
Coal, *Brookville* (?), reported thickness	1	8
Covered	15	--
Ore, *Black Flint* horizon	--	4
Covered	40	8
Coal, reported thickness	1	4
Covered	10	--
Ore, *Upper Mercer*	--	4
Covered	20	8
Coal, *Upper Mercer*, reported thickness	1	--
Covered	48	--
Coal, *Lower Mercer*, cannel nature, reported thickness	1	3

In Section 14, on land of W. R. Foster, the following members were seen:

	Ft.	In.
Ore, *Black Flint* horizon	--	6
Covered	34	--
Sandstone, shaly	1	--
Coal blossom, *Tionesta*	1	--
Clay, light, sandy	2	--
Sandstone	10	--
Ore, *Upper Mercer*	--	6
Sandstone and covered	21	6
Coal, *Upper Mercer*, reported thickness	1	6
Covered	4	6
Sandstone, shaly	5	--
Covered	2	--
Sandstone, shaly	4	--
Covered	6	--
Sandstone	5	--
Coal, bituminous	1	--
Covered	40	--
Coal, *Lower Mercer*, cannel	1	--

Coal Township.—East of the Grace mine, in Section 10, Coal Township, the thin cannel coal and the limestone are exposed in the bed of the small stream. The section obtained is as given below:

		Ft.	In.
Ore, *Upper Mercer*		--	4
Covered		10	--
Coal blossom.			
Clay shale		2	--
Shale and covered		11	--
Clay shale, sandy		2	--
Sandstone, shaly		7	--
Shale and covered		8	6
Coal		--	6
Clay		2	--
Shale		4	7
Ore, *Lower Mercer*		--	5
Shale		3	--
Covered		5	3
Shale, blue		5	--
Limestone	*Lower Mercer*	--	11
Shale, dark		1	10
Limestone		1	--
Covered		9	--
Coal, cannel, *Lower Mercer*		--	6
Covered		1	6
Top of shaft.			
Covered		97	--
Coal, *Quakertown*		3	--

The Lower Mercer bed, represented by about one foot of cannel coal, was seen in the creek bed near the top of the shaft on land of

R. S. and J. E. Thompson, in Section 12, Coal Township. The depth of the shaft is reported to be about 100 feet, but no exact information was obtained regarding this. The coal here is a tough cannel, the same as that seen south in Lick Township. The section obtained follows:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Covered	20	--
Sandstone	3	--
Coal, *Upper Mercer*	--	8
Covered	41	--
Shale	10	--
Coal, *Lower Mercer*, cannel	--	11
Clay	1	--
Top of air shaft.		
Interval reported, only approximate	100	--
Coal, *Quakertown*.		

The coal was also noticed at other points in this locality. North of Coalton and west of Wellston the bed was not observed, but in Washington Township the stratum is more persistent and better developed, for at a few places it is mined for a local domestic supply.

Washington Township.—In Section 24, Washington Township, on land of Clyde Foster, the Lower Mercer bed has been prospected by entry, but the coal was not seen as the roof had fallen. The following section was obtained:

	Ft.	In.
Limestone, *Lower Mercer*	1	--
Covered interval, only approximate	20	--
Coal and covered, *Lower Mercer*	2	--
Sandstone, shale and covered	53	--
Top of shaft.		
Interval reported	26	--
Coal, *Quakertown*, reported thickness	2	8

On the same ridge east of the above the outcrop of the cannel coal was noticed at a few places, but it was not measured. It occurs also farther west. Along the road that leads west from Hamden, in Section 13, the Lower Mercer limestone and coal were well exposed for measurement. A composite section taken there follows:

	Ft.	In.
Ore and blue fossiliferous limestone nodules, *Upper Mercer*	--	4
Shale	4	--
Shale with thin ore layers	3	--
Coal blossom	--	8
Clay, light	1	4
Shale, sandy	4	10
Ore, irregular, kidney	--	2
Sandstone, shaly	11	--
Shale and covered	8	--
Clay shale, light and pink	6	--
Shale and covered	6	6

		Ft.	In.
Ore	*Lower Mercer*	--	3
Shale		1	--
Ore		--	10
Shale, very fossiliferous		1	6
Shale		2	1
Limestone, *Lower Mercer*		--	10
Clay shale		2	--
Coal blossom		--	2
Shaly sandstone and covered		14	--
Ore, irregular, *Boggs*		--	6
Shale and shaly sandstone		3	--
Sandstone		--	3
Coal, *Lower Mercer*		1	1

A composite section taken along the road in Section 11 shows the relation of the Lower Mercer coal to higher members. The measurements taken are given below:

		Ft.	In.
Flint, black, fossiliferous, *Black Flint*		--	6
Shale, pink		1	--
Shale, dark		16	--
Shale, gray, sandy		14	--
Sandstone, shaly, very fossiliferous		3	--
Coal	*Tionesta*	--	5
Sandstone		--	6
Coal		--	5
Shale and covered		15	--
Sandstone, coarse-grained		5	--
Ore, *Upper Mercer*		--	6
Clay shale, light		1	6
Sandstone, shaly		14	--
Ore, kidney, *Sand Block*		--	2
Shale		2	4
Coal blossom, *Upper Mercer*		--	6
Sandstone, shaly		8	--
Covered		26	--
Clay shale, light		3	--
Coal blossom, *Lower Mercer*		1	--

In Section 10, on land of J. C. Reed, the Lower Mercer coal has been opened in the hollow, and above on the hill the blossom of the Tionesta coal, and a good exposure of the Black Flint, were seen. The Lower Mercer coal was reported to be 2 feet 2 inches thick. Just north of this and in the same section, on land of Robert Wilcox, the Lower Mercer coal is mined for local use. The bed is reported to have a thickness from 2 feet 4 inches to 2 feet 8 inches. The upper part of the stratum is represented by cannel coal, the thickness of which varies somewhat, but usually averages about 4 or 5 inches, while the coal in the remainder of the bed tends somewhat toward the cannel types. The following section was obtained at this point:

	Ft.	In.
Flint and ore, *Black Flint* horizon	1	--
Covered	24	--

Horizon of *Tionesta* coal.	Ft.	In.
Sandstone	23	--
Covered	15	--
Sandstone and covered	18	--
Ore.		
Covered	12	--
Ore, *Lower Mercer*	--	4
Covered	18	--
Shale, dark	4	--
Coal, *Lower Mercer*	2	6

This coal has also been mined on land of W. W. Manning. The thickness of the bed here is reported to be the same as that on the Wilcox property. The section obtained, and given below, shows several important members both above and below the Lower Mercer coal:

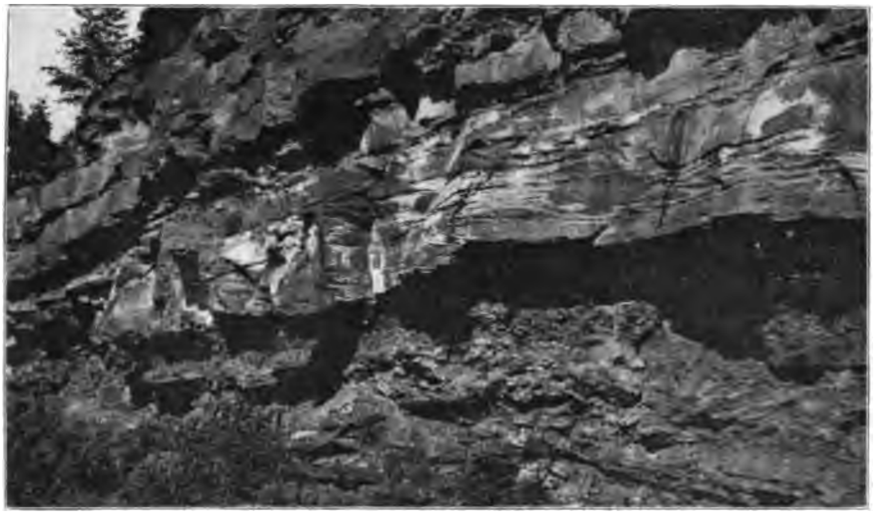
		Ft.	In.
Ore, *Black Flint* horizon		--	5
Sandstone and covered		30	--
Covered		10	--
Sandstone and covered		35	--
Covered		20	--
Ore, *Lower Mercer*		--	4
Shale and covered		27	--
Coal, *Lower Mercer*		2	4
Sandstone		15	--
Covered		23	--
Coal blossom, *Bear Run*, thickness reported		1	--
Sandstone and covered		36	--
Coal	*Quakertown*, reported thickness	1	8
Clay shale		--	4
Coal		--	6

Passing westward the bed thins, and at no place was it found to have any considerable thickness. It is usually represented by carbonaceous shales with siliceous clay below. The bed extends northward into Vinton County, but it was not followed far in that direction.

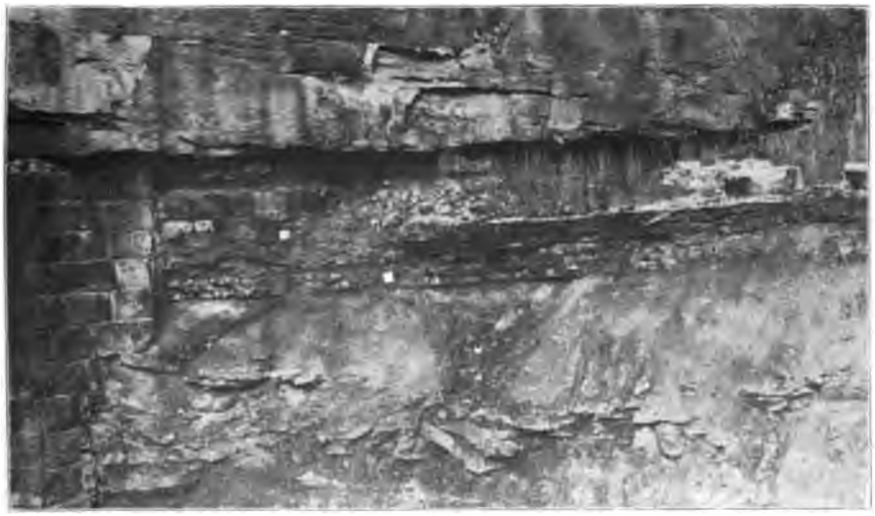
Economic Value

The Lower Mercer coal is of but little importance in Jackson County, for the areas in which the bed is of sufficient thickness for mining are small. Local pockets, which are worked in a small way, and in which the thickness of the deposit is from 1½ to 2½ feet, are found in a few sections in the northeastern part of Hamilton Township. Along the headwaters of Fourmile Creek in Franklin Township this stratum has been prospected at several points, but the coal is thin or bony. The horizon is marked more by the series of carbonaceous and bone shales than by coal strata.

The bed is regularly mined by drifting in one locality in northern Jackson County, and that is in Section 10, Washington Township, although at a number of places it has been benched in stream beds or



A.—Connoquenessing sandstone east of Richland Furnace in northern Jackson County.



B.—Clarion and Brookville coals in the tunnel of the Hocking Valley Railway near Oreton, Vinton County. The Clarion coal lies directly below the massive sandstone, and its lower bench is indicated by the upper white paper. The lower paper indicates the position of the Brookville coal, which here is only 1 foot 8 inches below the Clarion.

along the outcrop where the cover is shallow. In Section 10 the stratum has ample thickness for ease in mining, as the usual range is from 2 feet 2 inches to 2 feet 8 inches. The roof material here is a tough shale, while the floor material is a firm, siliceous clay, both conditions favorable for underground mining. In most of the area the bed is represented by dense cannel coal, or by both cannel and ordinary bituminous coal. In the cannel coal the ash is usually high, while in the bituminous part it is about that found in average coal. The bituminous part shows considerable sulphur in the form of pyrite or marcasite. The clay below the bed has but little economic value, as it is generally quite siliceous or shaly, and seldom more than 2 or 3 feet in thickness. The thickness and quality of the clay are not such as will justify its mining along with the coal for ceramic uses. The main value of the Lower Mercer coal is for small local domestic supplies.

BOGGS ORE

The position of the Boggs ore is either directly or only a few feet above the Lower Mercer coal. Apparently the ore was laid down during the same general swamp period in which the Lower Mercer coal was deposited. The member was observed at only a few places in Jackson County, but it is present in several small areas in northern Scioto County and has good volume. One measurement which was made along the road in Section 13, Washington Township, will be given in order to show the relation of this ore to other members. The section follows:

	Ft.	In.
Ore and blue fossiliferous, nodular limestone, *Upper Mercer*	--	4
Shale	4	--
Shale with thin ore layers	3	--
Coal blossom	--	8
Clay, light	1	4
Shale, sandy	4	10
Ore, irregular, kidney	--	2
Sandstone, shaly	11	--
Shale and covered	8	--
Clay shale, light and pink	6	--
Shale and covered	6	6
Ore	--	3
Shale } *Lower Mercer*	1	--
Ore	--	10
Shale, very fossiliferous	1	6
Shale	2	1
Limestone, *Lower Mercer*	--	10
Clay shale	2	--
Coal blossom	--	2
Shaly sandstone and covered	14	--
Ore, irregular, *Boggs*	--	6
Shale and shaly sandstone	3	--

	Ft.	In.
Sandstone	--	3
Coal, *Lower Mercer*	1	1

The deposits of Boggs ore in Jackson County are too small and the ore too impure to have any considerable value at present, but the bed was formerly worked in a small way by stripping for use in the old charcoal furnaces. Its interest at present lies chiefly in its value for stratigraphic work.

LOWER MERCER LIMESTONE AND ORE

The Lower Mercer limestone is found with some frequency in the northern part of Jackson County, but it is seldom present in the southern part. Its maximum development shows two benches of limestone, each approximately one foot in thickness and separated by about 2 feet of shale. The upper bench is more argillaceous and ferruginous than the lower, but not as persistent. Both strata are dense, dark blue, and moderately fossiliferous. The joint planes form the beds into more or less cubical or rectangular blocks, which on weathering are converted into rounded nodular masses. Along the outcrop or under shallow cover the blocks often show a surface layer of ferruginous material, which has replaced the calcium carbonate, and which varies in thickness from a thin scale to several inches. The iron ore found at some places on this horizon, from general appearances, represents the complete transformation of limestone to ore, which has taken place through the action of ground waters.

The interval from the Lower Mercer or Little Red Block ore to the Lower Mercer limestone when both are present varies from 1 to 18 feet, but the average interval is about 8 feet. The ore in the southern part of Jackson County, although wanting in large areas, is far more constant than the limestone which is seldom present. This is also the condition found in Scioto and Lawrence counties. In the northern part of Jackson County both ore and limestone are relatively constant, but vary in character and thickness. The ore is not a part of the limestone formation but a separate and distinct stratum, deposited under somewhat similar conditions, yet differing in composition and date of origin. The ore was deposited as ferrous carbonate, while the limestone was laid down as a calcium carbonate, yet both are of swamp or shallow sea origin. The ore was also formed somewhat later than the limestone, as the two are often separated by several feet of rock material. Both limestone and ore are fossiliferous and contain the same types of life.

In Jackson County the interval from the Lower Mercer limestone to the Lower Mercer ore averages almost 8 feet; to the Upper Mercer coal the interval varies from 23 to 35 feet, but averages about 27 feet; to the Sand Block ore the interval varies from 30 to 45 feet, but averages about 36 feet; and to the Upper Mercer ore the interval varies from 43 to 60 feet, but averages 51 feet. The order and average intervals found are as given below:

	Ft.	In.
Ore, *Upper Mercer.*		
Interval	15	--
Ore, *Sand Block.*		
Interval	9	--
Coal, *Upper Mercer* or *No. 3a.*		
Interval	19	--
Ore, *Lower Mercer.*		
Interval	8	--
Limestone, *Lower Mercer.*		

Hamilton Township.—Sections showing the relation of the Lower Mercer limestone and ore to various other members will be given. On land of Fred Raymond, Section 36, the following members were seen:

	Ft.	In.
Limestone, *Ferriferous*, seen on outcrop	3	--
Covered	47	--
Shale	8	--
Covered	6	--
Sandstone, massive	24	--
Covered	26	--
Ore, *Sand Block*	--	5
Shale and covered	11	--
Coal blossom, *Upper Mercer*	1	--
Clay and covered	3	--
Sandstone	12	--
Covered	12	--
Ore, *Lower Mercer*	--	4

An iron ore, blocky and very fossiliferous, which appears to have been derived from weathering of the Lower Mercer limestone, was found near the summit of the hill on land of Edward Gahm, in Section 11. The relation to the coals below is shown in the following section:

	Ft.	In.
Ore, *Lower Mercer*	--	6½
Covered	35	--
Shales	5	--
Sandstone, fissile	--	8
Clay shales, light	2	8
Limestone, bastard, blue	1	--
Shales, *Lower Mercer* coal horizon, near top	35	--
Covered	10	--
Shales	4	--
Coal, *Vandusen*	1	--

Scioto Township.—A section taken on land of Andrew Yinger, in Section 13, Scioto Township, shows the following members:

	Ft.	In.
Ore, *Upper Mercer*, fossiliferous	--	5
Sandstone, ferruginous	--	8
Coal	--	6
Shale and covered	22	--

	Ft.	In.
Coal, *Upper Mercer*	1	--
Shale and covered	12	--
Coal blossom	--	5
Clay shale	1	9
Ore, *Lower Mercer*	--	3
Coal blossom	1	--
Clay	3	--
Shale	27	--
Covered	3	5
Bone shale	--	7
Sandstone, light	6	--
Shale, blue	34	2
Shale, sandy, blue	3	--
Coal, *Vandusen*	--	10
Clay and sandy shale	4	--

A section taken on lands of T. A. Henderson, in Section 1, Scioto Township, shows the following members:

	Ft.	In.
Ore, *Lower Mercer*, fossiliferous	6	--
Covered	86	--
Ore, *Jackson Sand Block*, thickness reported	1	--
Shale	8	--
Coal and bone, *Bear Run*, reported thickness	2	4
Shale	8	--
Sandstones, flaggy	24	--
Covered	5	--
Coal, cannel, *Quakertown*	--	6

Franklin Township.—On land of James Mayhew, in Section 5, Franklin Township, the Lower Mercer ore with two coals below were seen and measured. The section follows:

		Ft.	In.
Ore, *Lower Mercer*, blocks seen		--	4
Covered		13	--
Shale, gray		8	--
Shale, blue, tough		6	--
Coal blossom.			
Shale, gray, sandy		7	--
Coal blossom, *Lower Mercer*, part cannel		1	6
Clay shale		2	6
Shale		13	--
Sandstone		24	--
Shale, sandy		3	--
Coal, good	*Vandusen*	--	11
Clay shale		--	3
Coal		--	1
Clay shale		1	6

South of the standpipe, on property of Peter Radcliff, in Section 3, the following section was seen:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Covered	28	4

	Ft.	In.
Shale	3	--
Limestone, *Lower Mercer*	--	8
Clay shale, light	1	--
Shale with parts covered	22	--
Shale	10	--
Coal, cannel, *Lower Mercer*	1	--

Lick Township.—In Section 23, Lick Township, on land of Bentley Miller, three ores are present, and the intervals measured are as follows:

	Ft.	In.
Ore, *Black Flint*	--	3
Covered	18	--
Coal blossom, *Tionesta*	1	--
Covered	31	--
Ore, *Upper Mercer*	--	6
Covered	51	--
Ore, *Lower Mercer*	--	4

In the vicinity of Young America Furnace the Lower Mercer limestone was found in several places. The following section was obtained on the property of Oscar Evans, in Section 15:

	Ft.	In.
Coal blossom, *Tionesta*.		
Clay shale	3	--
Sandstone and covered	10	--
Ore, *Upper Mercer*	--	5
Clay shale	3	--
Covered	40	--
Shale	4	--
Ore	--	2
Shale	--	2
Limestone, *Lower Mercer*, fossiliferous	1	--

Near the home of George B. Wycle, in Section 14, Lick Township, the Lower Mercer limestone was exposed along the roadside, and, near the summit of the hill just north, the Upper Mercer and Black Flint ores were seen in an old road. The section measured is given below:

	Ft.	In.
Ore, *Black Flint*, reported thickness	--	6
Covered	15	--
Sandstone, calcareous, fossiliferous	1	--
Covered	3	--
Coal blossom, *Tionesta*	1	--
Clay, light	7	--
Shale	4	--
Sandstone	9	--
Coal blossom	1	--
Clay, bluish, sandy	2	--
Shale, sandy	5	--
Ore, *Upper Mercer*	--	2
Coal stain.		
Clay, light, sandy	2	--

	Ft.	In.
Sandstone, light	8	8
Covered	5	--
Ore, irregular, kidney, *Sand Block*	--	2
Shale	6	8
Coal, *Upper Mercer*	1	1
Clay, good	3	--
Shale	9	11
Coal	--	4
Clay shale	2	8
Sandstone	3	--
Shale	3	--
Coal	--	9
Clay shale	2	--
Covered	5	3
Limestone, *Lower Mercer*, lower bench, fossiliferous	1	--

Coal Township.—East of Grace mine, Section 10, Coal Township, the limestone was exposed in the creek bed, and the ore seen in the road above. The section measured is as given below:

		Ft.	In.
Ore, *Upper Mercer*		--	4
Covered		10	--
Coal blossom.			
Clay shale		2	--
Shale and covered		11	--
Clay shale, sandy		2	--
Sandstone, shaly		7	--
Shale and covered		8	6
Coal blossom		--	6
Clay		2	--
Shale		4	7
Ore, *Lower Mercer*		--	5
Shale		3	--
Covered		5	3
Shale, blue		5	--
Limestone	*Lower Mercer*	--	11
Shale, dark		1	10
Limestone		1	--
Covered		9	--
Coal, cannel, *Lower Mercer*.			
Covered		1	6
Top of shaft.			
Covered		97	--
Coal, *Quakertown*		3	--

Along the road, in Section 36, south of the abandoned Superior No. 2 mine, the Lower Mercer limestone with the ores above were exposed, and the measurements taken are given below:

	Ft.	In.
Ore, *Upper Mercer*, thickness reported	--	5
Covered	35	--
Ore, *Lower Mercer*	--	4
Clay shale, light	1	8

	Ft.	In.
Gray shale and covered	16	--
Limestone, *Lower Mercer*	1	--
Shale, gray	2	--
Clay shale, light	11	--
Coal blossom, *Lower Mercer*	1	--
Clay	2	--
Sandstone.		

The limestone and ore were observed at several places in the vicinity of Coalton. The most western exposure noted was on the ridge in the western part of Section 5. On land of W. R. Hamilton, in Section 27, the Lower and Upper Mercer ores have been mined by stripping. The following record was obtained here:

	Ft.	In.
Sandstone and covered	20	--
Ore, *Upper Mercer*	--	4
Sandstone and covered	10	--
Covered	20	--
Coal blossom, *Upper Mercer*	1	--
Clay and covered	7	--
Sandstone and covered	10	--
Ore, *Lower Mercer*, fossiliferous	--	6
Covered.		

Washington Township.—In Section 23, Washington Township, on land of E. C. Wallace, the upper part of a section taken is as given below:

	Ft.	In.
Sandstone and covered	30	--
Shale	10	--
Ore, *Black Flint* horizon	--	6
Shale, very fossiliferous	10	--
Coal blossom, *Tionesta*	--	6
Clay and covered	3	6
Sandstone, soft	38	--
Ore and flint nodules, *Upper Mercer*	--	4
Shale, gray	13	6
Coal blossom	--	6
Clay, light, sandy	2	--
Sandstone shaly	7	--
Shale, gray	6	8
Ore, siliceous, *Sand Block*	--	4
Sandstone, ferruginous	2	--
Clay, light, sandy, *Upper Mercer* coal horizon	5	--
Shale, gray	4	--
Sandstone, shaly	2	8
Shale, gray	--	10
Ore, *Lower Mercer*	--	2
Shale, gray	2	4
Sandstone, light	3	--
Shale, dark	9	--
Shale, with thin coal bands	3	--

	Ft.	In.
Shale, blue	1	2
Shale, with thin cannel coal layers, *Lower Mercer* coal horizon	--	10

Along the road west of Hamden, in Section 13, Washington Township, the Lower Mercer limestone and ore are well represented, and the horizon of the Upper Mercer limestone is marked by dark flinty limestone nodules and kidney ore. The section measured at this place is given below:

	Ft.	In.
Sandstone	11	--
Ore and flinty limestone, *Upper Mercer*	--	4
Shale	4	--
Shale with thin ore layers	3	--
Coal blossom	--	8
Clay, light	1	4
Shale, sandy	4	10
Ore, kidney, *Sand Block*	--	2
Sandstone, shaly	11	--
Shale and covered	8	--
Clay shale, light and pink	6	--
Shale and covered	6	6
Ore } *Lower Mercer*	--	3
Shale } *Lower Mercer*	1	--
Ore } *Lower Mercer*	--	10
Shale, very fossiliferous	1	6
Shale	2	1
Limestone, *Lower Mercer*	--	10
Clay shale	2	--
Coal	--	2
Shaly sandstone and covered	14	--
Ore	--	6
Shale and shaly sandstone	3	--
Sandstone	--	3
Coal, *Lower Mercer*	1	1
Clay and covered.		

The limestone and ore extend westward to the high knobs and ridges south of Richland Furnace and east of Pigeon Creek, but were not seen west of that stream.

Milton Township.—In northwestern Milton Township the Lower Mercer limestone is moderately persistent, more so than the Lower Mercer ore. At some places the former is made up of two layers of limestone, separated by from 1 to 3 feet of shales, usually very fossiliferous. The lower layer is dark blue in color, very hard and only moderately fossiliferous, while the upper layer is much lighter in color, ordinarily a dark gray, more shaly, and very fossiliferous. The lower layer is much more persistent than the upper layer, and usually thicker. The upper layer is reduced readily by weathering, so it is found only under favorable conditions. A few sections will be given to show the relation of the Lower Mercer limestone to other members.

The section measured from the mine of the Domestic Coal Company to the hill east shows the Lower Mercer limestone and the intervals from it to the Quakertown, Upper Mercer, Brookville, and Clarion coals. The section obtained follows:

	Ft.	In.
Limestone, *Ferriferous*	5	--
Coal blossom, *Clarion*	4	--
Clay and shale	5	--
Coal blossom, *Brookville*	2	6
Clay and covered	8	6
Covered	17	--
Sandstone	5	--
Covered	38	--
Sandstone	11	--
Coal, *Upper Mercer*	--	6
Sandstone	20	--
Sandstone, shaly	10	--
Limestone, *Lower Mercer*	1	--
Covered	4	--
Top of shaft.		
Interval	87	--
Coal, *Quakertown*	3	4

Near the mine of the Wellston Colliery Company, in Section 5, the two Mercer ores were found, and only a short distance west the Lower Mercer limestone was exposed close below the lower ore. At the mine of the Elk Fork Coal Company, in Section 3, the Lower Mercer limestone with other important members were exposed, and the record obtained is given below:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Shale	9	2
Coal, *Upper Mercer*	1	6
Sandstone, shaly	5	--
Top of shaft.		
Sandstone and covered	25	--
Limestone, *Lower Mercer*	1	--
Shale	7	--
Coal, *Lower Mercer*	--	4
Interval	88	--
Coal, *Quakertown*	2	3

A very good section of the members above the Lower Mercer limestone was obtained from the hollow near the abandoned No. 6 Superior mine to the point west on land of George Woodrow. The intervals separating the members in the section given below are about normal for the region:

		Ft.	In.
Ore, *Ferriferous*.			
Shale, black		3	--
Coal	*Clarion*, reported thickness	1	2
Clay and bone coal		--	8
Coal		1	--
Clay-sulphur band		--	1
Coal		1	--

	Ft.	In.
Covered	51	--
Coal blossom, *Tionesta*	1	--
Covered	31	--
Ore, *Upper Mercer*	--	4
Covered	35	--
Shale, part sandy	16	--
Covered	5	--
Limestone, *Lower Mercer*	--	10
Covered.		

A measurement taken along the road on the line of sections 18 and 19 shows the interval from the Lower Mercer to the Ferriferous limestone to be considerably less than the average for the region. The section given below records the measurements:

		Ft.	In.
Limestone, *Ferriferous*, flinty		3	--
Shale, black, fissile		2	--
Coal	*Clarion*	1	2
Coal, bony		--	4
Clay		--	6
Coal		1	5
Clay-sulphur band		--	1
Coal		1	--
Clay and covered		13	--
Sandstone		9	--
Covered		10	--
Sandstone, soft		12	--
Shale		1	6
Ore, *Upper Mercer*		--	3
Clay, light		1	3
Sandstone		1	--
Covered		5	--
Ore, *Sand Block*		--	4
Sandstone, ferruginous		--	8
Sandstone, soft		10	--
Covered		5	--
Sandstone		11	--
Clay, light		2	--
Sandstone		3	--
Sandstone, coarse-grained		5	6
Shale		1	6
Limestone, *Lower Mercer*		1	--
Shale, dark		2	--
Covered		3	--
Shale gray		6	--
Covered		2	--
Level of track of B. & O. R. R.			

South of Berlin the limestone soon passes below drainage.

Economic Value

The Lower Mercer limestone and ore are of more interest for their utilization in the manufacture of iron during the charcoal furnace period than for their present value. The ore is rich, easily reduced, and contains the elements necessary for making a soft, high grade, foundry iron; hence it was always in demand for charcoal iron. Although the stratum is thin the ore was worked along the outcrop and under shallow cover by benching, the old rule being to strip a foot of dirt for an inch of ore. No mining of the Lower Mercer ore is done at present in Jackson County as the high-grade Lake ores are used instead. The iron content of the ore in the natural state runs from 35 to 50 per cent, the phosphorus from .250 to .400, and the manganese from .30 to .60.

The Lower Mercer limestone, found in some quantity only in the northern part of Jackson County, was but little used as a flux stone, as the better Ferriferous limestone was available in most localities. Small amounts were mined for this purpose near Young America Furnace, where the limestone has a fair thickness, and is found on the hills near the old stack. The limestone in some localities is moderately pure, while at other places it is siliceous and flinty. The following analysis represents that of the better grades of stone:[1]

Silicic acid	5.40
Sesquioxide of iron and alumina	2.00
Calcium carbonate	88.00
Magnesium carbonate	1.51
Water	2.90
Total	99.81

The dense tough nature of the limestone recommends it for road building and for concrete work, but as the member is thin the more available Ferriferous limestone is used instead. In Jackson County the lower layer seldom reaches 2 feet in thickness, and averages only about 1 foot, while the maximum thickness of the upper layer where exposed was only 1 foot. Along the outcrop the lower layer is broken by vertical joints into blocks, which are used to some extent for foundations and walls. The Lower Mercer limestone is of great aid in the correlation of the various members in the Pottsville, and is used as the main bench mark stratigraphically, for it can be recognized with certainty. At present the Lower Mercer ore and limestone are economically unimportant.

UPPER MERCER, WEBSTER BLOCK, OR No. 3a COAL AND CLAY

The Upper Mercer, or No. 3a coal, seldom wanting, but usually thin, extends across Jackson County from Scioto and Lawrence on the south to Vinton on the north. The coal is usually of excellent quality, and where the bed thickens sufficiently for mining the local fuel supply, in part at least, is drawn from this source. The Upper Mercer coal will be of more importance in the future when the thicker deposits are exhausted; hence this stratum with the associated rocks in the localities in which it is best developed will be described and traced.

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[1] Geol. Surv Ohio, Rep. for 1870, p. 152.

The Upper Mercer coal is found in parts of Hamilton, Jefferson, Scioto, Franklin, Bloomfield, Lick, Coal, Milton, and Washington townships. It is best developed however in local areas in Jefferson, Scioto, Lick, and Bloomfield townships, where it is mined by drifting for local use.

Hamilton Township.—The horizon of the Upper Mercer coal in the eastern part of Hamilton Township is well towards the summits of the hills, and although observed at a number of places the deposit was everywhere thin and of little value. On land of Fred Raymond, in Section 36, the rocks exposed are as follows:

	Ft.	In.
Limestone, *Ferriferous*	3	--
Covered	49	--
Shales	8	--
Covered	6	--
Sandstone, massive	24	--
Covered	26	--
Ore, *Sand Block*	--	5
Shales and covered	11	--
Coal, *Upper Mercer*	1	--
Clay and covered	3	--
Sandstone	12	--
Covered	12	--
Ore, *Lower Mercer*	--	4

Jefferson Township.—In Jefferson Township the bed thickens locally and is mined by drifting in Section 8 where the deposit is known as the Jones coal. It is also worked by benching at other places. Near the head of Laurel Fork, sections 29 and 30, on lands of A. Kelley and John Jaycox, a composite section showing the Upper Mercer and Tionesta coals is as given below:

		Ft.	In.
Shale, gray, sandy, fossiliferous		6	--
Shale, dark, tough		11	--
Coal, good	*Tionesta*	1	3
Coal, bony		--	6
Coal, good		2	2
Coal, cannel		--	3
Covered		21	--
Sandstone, massive		20	--
Shale, blue		4	--
Coal, *Upper Mercer*, reported to reach 1 foot 6 inches		--	6
Covered.			

In Diamond and Slab Hollows the coal was exposed in several places, and is about 1 foot in thickness. A good exposure of the strata was seen on land of Ernest Lahrmer, Section 32, where the coal had been mined by stripping. The rocks measured are as follows:

		Ft.	In.
Coal blossom.			
Clay shale		2	--
Covered		3	--
Sandstone		28	--
Shale		1	3
Ore, *Sand Block*		--	5
Shale, gray		1	7
Shale, blue		2	9
Coal, good	*Upper Mercer*	--	10
Coal, bony		--	1
Shale		--	4
Covered		1	8
Sandstone, massive		10	--

On land of A. C. Arthur near the cross roads, in the northwestern corner of Section 20, the Upper Mercer coal has been stripped for local use. The interval from the Upper Mercer to the Tionesta coal is 52 feet. Just north of the above, and in the same section, on the land of Robert Sims, the coal measured 1 foot 6 inches in thickness.

On the property of Stephen Jones, Section 8, the Upper Mercer coal has been regularly mined by drifting for years. The bed which is from 22 to 26 inches in thickness is persistent. A section taken in this locality shows the following rocks:

	Ft.	In.
Sandstone and covered	17	--
Shales	8	--
Clay and clay sandstone, light, *Tionesta* coal horizon	7	--
Sandstone	8	--
Covered	6	--
Sandstone, massive	18	--
Ore, *Upper Mercer*	--	2
Shales and covered	8	10
Ore, *Sand Block*	--	4
Shales	9	8
Coal, *Upper Mercer*	1	10
Clay, good, light	2	--
Sandstone	25	--

This coal has been mined near the Horten School also. Along Hewitt Run east of the Jones deposit the coal thins, or is replaced by heavy sandstones. On Black Fork, in Section 3, on land of Evan Jenkins, a good exposure of the coal was noted which measured as follows:

		Ft.	In.
Sandy clay		3	--
Shale		3	--
Ore	*Upper Mercer*	--	4
Sandstone		--	1
Ore		--	2
Cherty sandstone		--	1

	Ft.	In.
Coal	--	1
Covered	13	3
Shale	4	--
Ore, *Sand Block*	--	6
Shale	6	--
Coal, *Upper Mercer*	1	2
Clay.		

Scioto Township.—In Scioto Township the Upper Mercer coal thickens locally in sections 13 and 24. At several places in the latter section the coal is mined by drifting for the local supply. On land of John Messing, Section 24, Scioto Township, the section recorded follows:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Shales and covered	28	--
Coal, *Upper Mercer*, reported thickness	2	6
Covered	5	--
Sandstone	23	--

The coal is mined also on the A. W. Jacobs farm in the same section. In Section 13, on the land of Andrew Yinger, the upper part of a section taken shows the following members:

	Ft.	In.
Shales	8	--
Ore, *Upper Mercer*, fossiliferous	--	5
Sandstone, ferruginous	--	8
Coal	--	6
Shales and covered	22	--
Coal, *Upper Mercer*	1	--
Shales and covered	12	--
Coal	--	5
Clay shales	1	9
Ore, *Lower Mercer*	--	3
Clay	3	--

Franklin Township.—Where seen in the western part of Franklin Township, in which territory the horizon is above drainage, the Upper Mercer coal is too thin to be mined at present, except by stripping along the outcrop. The clay is usually better represented than the coal. The horizon of this bed is also above drainage in the northeastern part of the township, but in this locality it is thin, or replaced by heavy sandstones.

Lick Township.—In the eastern part of Lick Township the Upper Mercer coal is locally developed in small areas, and is worked for domestic use. A good exposure of the coal was noted on the land of Harrison Kesinger, Section 26. The rock strata measured are as follows:

	Ft.	In.
Ore, *Black Flint* horizon, reported thickness	--	6
Covered	58	--
Ore, *Upper Mercer*	--	4

	Ft.	In.
Covered	15	--
Sandstone, shaly	8	--
Coal, *Upper Mercer*	1	8

This coal has also been worked on the properties of Clinton Aleshire and Martin Foster, and is reported to have about the same thickness as that seen in the above section. The structure of the coal was seen in a mine on the Madison Wykle property, in Section 22. The following members were recorded:

		Ft.	In.
Ore, *Black Flint* horizon		--	6
Covered		48	--
Ore, *Upper Mercer*		--	5
Covered		25	--
Sandstone		8	--
Shale		1	6
Coal	*Upper Mercer*	--	5
Clay parting		--	2
Coal		1	5
Covered		36	--
Coal, cannel, *Lower Mercer*		--	3
Shales and covered		29	--

East of the above in the same section, on land of George B. Wykle, the Upper and Lower Mercer limestones, the Upper Mercer coal, and two ores are shown in the carefully measured section which follows:

	Ft.	In.
Sandstone	15	--
Ore, *Black Flint* horizon	--	6
Covered	15	--
Sandstone, calcareous, fossiliferous	1	--
Covered	3	--
Coal blossom, *Tionesta*	1	--
Clay, light	7	--
Shale	4	--
Sandstone	9	--
Coal blossom	1	--
Clay, sandy, dark	2	--
Shale, sandy	5	--
Ore, *Upper Mercer*	--	2
Coal stain	--	1
Clay, light, sandy	2	--
Sandstone	8	8
Covered	5	--
Ore	--	2
Shale	6	8
Coal, *Upper Mercer*	1	1
Clay, good	3	--
Shale	9	11
Coal	--	4
Clay shale	2	8
Sandstone	3	--

	Ft.	In.
Shale	3	--
Coal	--	9
Covered	5	3
Limestone, *Lower Mercer*, fossiliferous	1	--

Coal Township.—The Upper Mercer coal is present in the eastern part of Coal Township. The coal is usually very thin, often only a smut streak, but the clay below in some localities is from 4 to 6 feet in thickness, and of good quality for many ceramic purposes. The coal was opened on the G. N. House property, in Section 3. A composite section taken from the mine to the point west shows other members above the Upper Mercer coal, and the measurements obtained are given below:

		Ft.	In.
Covered		15	--
Ore, *Black Flint* horizon		--	8
Covered		25	--
Sandstone, shaly, very fossiliferous		4	--
Shale, sandy, very fossiliferous		1	3
Shale, dark, very fossiliferous		--	4
Coal	*Tionesta*	1	2
Clay shale with thin coal bands		--	6
Coal		--	5
Clay, dark		--	11
Coal		--	10
Clay shale, dark		1	6
Covered		14	--
Ore, *Upper Mercer*		--	4
Sandstone and covered		26	--
Shale		2	10
Coal, *Upper Mercer*		1	2

At this place the coal is reported to be somewhat thicker farther in the hill. North of this the outcrop of the member, represented by coal or clay, was noticed at a number of places.

Washington Township.—The Upper Mercer coal and clay are present in eastern Washington Township; although the coal is generally thin the clay in most of the area has good volume. A small amount of coal has been mined from this bed just west of the Town House, in Section 21, Washington Township. The record taken is given below:

	Ft.	In.
Flint, *Black Flint*	1	--
Shale and covered	18	--
Shale	3	--
Coal blossom, *Tionesta*	1	--
Clay, sandy	2	--
Sandstone, soft	37	--
Covered	14	--
Shale, dark	6	--
Coal, *Upper Mercer*	1	--

	Ft.	In.
Covered	3	--
Shale, sandy	8	--
Covered	4	--
Sandstone	12	--
Ore, *Lower Mercer*.		

East of this, in Washington Township, the clay is generally several feet in thickness, but the coal, where observed, was thin and bony.

Milton Township.—In northern Milton Township the Upper Mercer coal is unsteady, as it is often replaced by massive sandstones. In Section 32, near the mine of the Domestic Coal Company, the member is seen giving way to the sandstones. This condition is also again found in Section 33, near the No. 12 Superior mine. The lower part of a section measured here is as follows:

	Ft.	In.
Limestone, *Ferriferous*	4	--
Covered	2	--
Coal blossom, *Clarion*	4	--
Sandstone, clay-bond	4	--
Coal blossom, *Brookville*	2	--
Clay and covered	4	--
Coal blossom	--	2
Clay, light	3	10
Shales, sandy	12	--
Covered	13	--
Coal blossom, *Tionesta*	--	6
Clay shales	1	6
Sandstone, massive	60	--
Disconformity.		
Coal, *Upper Mercer*	1	2
Sandstone, shaly	7	--

The coal goes below drainage near the old stack of Lincoln Furnace. In the southwestern part of Section 2, on the land of the Superior Colliery Company, the coal and Upper Mercer ore were well exposed. The section taken at this place, and given below, shows the general relations:

		Ft.	In.
Limestone, *Ferriferous*.			
Shale, dark.			
Shale, dark, fissile		1	2
Coal	*Clarion*	1	3
Clay and bone coal		--	7
Coal		1	4
Clay-sulphur band		--	1
Coal		1	2
Covered		19	--
Coal blossom		--	6
Covered		22	--
Sandstone		6	--
Disconformity.			
Shale		4	--
Ore, *Upper Mercer*		--	4

	Ft.	In.
Shale	7	8
Sandstone, nodular, ferruginous	--	6
Shale	5	--
Clay shale, dark	3	--
Sandstones	2	--
Coal, *Upper Mercer*	1	4
Clay	1	--
Shale	6	--

At the mine of the Elk Fork Coal Company, in Section 3, the Upper Mercer coal and ore are exposed in the railroad cut, and the Lower Mercer limestone is exposed in the manway. East of Mulga Run, in Section 10, on the land of the Superior Colliery Company, the coal has been stripped in the bed of a small stream where it was 1 foot 6 inches thick. The coal is thin where observed along Little Raccoon Creek, south of the above, and goes below drainage near the mouth of Coal Run.

Bloomfield Township.—The Upper Mercer coal is above drainage along Dickason Run in the vicinity of Ridgeland. On the land of Harriet A. and W. L. Burris it is mined for local use. The bed in this locality varies from 1 foot 6 inches to 2 feet 2 inches in thickness, the coal is of excellent quality, furthermore the mining conditions are good, as the roof is a tough shale. At this place the Tionesta coal lies close to the Upper Mercer, for the two beds are separated by only 18 feet of shales and sandstones. A carefully measured section taken shows the following relations:

		Ft.	In.
Limestone, *Ferriferous*		4	--
Covered		49	--
Ore, *Black Flint* horizon		--	10
Covered		8	--
Shale, gray		3	--
Shale, sandy, very fossiliferous		4	--
Shale, dark		4	--
Sandstone, dark		--	4
Shale, black, bony		2	--
Coal, good	*Tionesta*, thickness reported	--	10
Clay		--	10
Coal, good		1	2
Covered		8	2
Shale, sandy		9	--
Shale, draw slate		--	4
Coal, *Upper Mercer*		1	11
Clay		--	6
Sandstone, clay-bond.			

The fields in which the Upper Mercer coal is most promising are the local areas in western Jefferson Township, in southeastern Scioto, especially in Section 24, in northeastern Lick, and in eastern Bloomfield.

The bed is unsteady in Milton Township, and it is usually quite thin in Coal and Washington townships.

Economic Value of Upper Mercer Coal

The worth of the Upper Mercer coal, now of value in some localities for domestic fuel, will increase as the thicker coals become exhausted. Although the bed is thin the coal is of excellent quality, and the conditions are favorable for mining. The member is made up of one coal bench with occasionally a thin layer above or below, separated from the main block by a few inches of clay or clay shale. The roof of the bed, with few exceptions, is a blue shale, sufficiently tough and solid for safety and efficiency in mining, but in a few localities it is made up of a sandstone with a thin shale below, which in wet mines loosens and falls. The floor of the deposit is clay, which, varying from the soft plastic to the somewhat harder siliceous types, is easily removed for entry ways, and has a ceramic value. The usual method of mining is to cut in the clay below, or in the clay partings when two coal benches are present, and thus separated, to loosen the coal which lies in blocks by either wedging or shooting. In the Jones mine, in Section 8, Jefferson Township, about one foot of the clay below is loosened by shooting and then removed, after which a small shot placed near the top of the stratum loosens the coal with but little shattering.

The coal is rather fragile, but as the bed has a jointed or blocky structure it mines, when care is taken on the part of the workmen, in lumps, with only a small amount of loss from fine material. It is a bright, clean looking coal, with low sulphur and ash, of which the latter is light-colored and non-clinkering under ordinary conditions. The coal ignites readily and burns with a long free flame. The Upper Mercer coal, when all points are considered, is an excellent fuel, well adapted for general uses, and especially so for domestic purposes.

Mr. Burris kindly furnished an analysis of the coal from their mine in Section 7, Bloomfield Township. The analytical work was done by J. G. Harding, chemist for the Wellston Iron & Steel Company. The analysis of the sample dried at 212° F. is as follows:

Volatile matter	39.40
Fixed carbon	57.00
Ash	3.60
Sulphur	.69

Economic Value of Upper Mercer Clay

The Upper Mercer clay, which lies directly below the Upper Mercer or Webster Block coal, varies in thickness and quality, but it has a ceramic value and is an asset, especially when both clay and coal are considered. The thickness of the deposit varies from 2 to 6 feet, and the material varies in quality from a plastic, low siliceous clay to one quite sandy. It is a second-grade fire clay with a moderate amount of fluxes and coloring agents, and is well fitted for the manufacture of high-grade building brick. When the clay is carefully selected it is also suitable for stoneware and low-grade fire brick. When mined in conjunction with the coal above the cost of winning the clay is low. In some localities where the coal bed has a fair thickness the fuel obtained would be sufficient to manufacture and burn the ware made from the clay.

SAND BLOCK ORE

In Jackson County the next member above the Upper Mercer coal is the Sand Block ore, which, although of little value at present, was worked in a number of localities for the smelting of iron in the old charcoal furnaces, but it was then ranked far below the Ferriferous and Upper Mercer ores. The ore is found more or less continuous in parts of Hamilton, Jefferson, Scioto, Franklin, Lick, Coal, Washington, Milton, and Bloomfield townships. In the townships south of Jackson the Sand Block ore lies from 10 to 20 feet above the Upper Mercer coal, and from 10 to 20 feet below the Upper Mercer ore, while north of Jackson these intervals are somewhat contracted, as the ore is often found lying just above the Upper Mercer coal. The relation of the ore to other members is shown in the sections under the Upper Mercer coal, hence they will not be repeated. The thickness of the ore varies from an inch or two to a foot or more in some localities, but the average measurement is about 5 inches. The ore is generally siliceous and low in iron, but in most cases the thicker the deposit the leaner the ore. Under heavy cover the iron is in the form of the carbonate, but along the outcrop, or where affected by percolating waters, it has been changed to hydrated oxides. At present the Sand Block ore adds but little to the mineral wealth of the county.

UPPER MERCER LIMESTONE AND ORE AND ASSOCIATED STRATA

The Upper Mercer limestone is seldom present in Jackson County, but the ore, except where replaced by the heavy sandstones, is quite persistent, and may be traced across the county from Scioto and Lawrence on the south to Vinton on the north. The horizon is found near the summits of the hills and ridges in the eastern parts of Hamilton and Scioto townships, and owing to the dip eastward it goes under cover in the eastern parts of Jefferson and Franklin townships. It is found in the eastern halves of Lick, Washington, and Coal townships, and, extending eastward, it goes below drainage in northern Bloomfield and eastern Milton along the courses of Little Raccoon Creek and its tributaries. The horizon is found in Washington Township well toward the summits of the main ridges. Besides the Upper Mercer limestone and ore, thin coals with clays are present in the sandstones and shales.

Stratigraphy

The Upper Mercer limestone is sparingly fossiliferous and of marine origin, as the types represented are of this character. The associated ore also carries fossils of the same types as those found in the limestone. The exact relation of limestone to ore is hard to determine, as the latter is so seldom found, but the exposures observed indicate that the two beds are closely associated. The relation of the Upper Mercer ore to other members, and the average intervals separating them, are given in the following general section for Jackson County:

	Ft.	In.
Flint and ore, *Black Flint* horizon	1	--
Shales and sandstones	21	--
Coal, *Tionesta No. 3b*	2	--
Shales and sandstones	27	6
Ore, *Upper Mercer*	--	6
Shales and sandstones	14	8
Ore, *Sand Block*	--	4
Shales and sandstones	8	6
Coal, *Upper Mercer No. 3a*	1	6
Shales and sandstones	18	--
Ore, *Lower Mercer*	--	4
Shales and sandstones	7	8
Limestone, *Lower Mercer*	1	--

Many local variations in intervals were observed, as the Mercer rocks in Jackson County are very irregular. When the intervals are made up of shales, the positions of the members are usually quite constant, but when the massive sandstones appear many abnormalities of the positions are found. In a general way there is a gradual thinning of the intervals northward across the county, and this condition is also found in Scioto and Lawrence counties. A series of sections will be given tracing the horizon across the county.

Hamilton Township.—In Section 35, Hamilton Township, on the land of Henry Comer, the position of the Upper Mercer ore with reference to other members is shown in the following record:

	Ft.	In.
Shales.		
Coal blossom, *Tionesta*	1	--
Covered	25	--
Ore, *Upper Mercer*	--	6
Covered	17	--
Ore, *Sand Block*	--	3
Covered	45	--
Ore, *Lower Mercer*	--	2

On the land of Joseph Woods, in Section 24, in the eastern part of the township, the measurements were as follows:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Covered	13	--
Ore, *Sand Block*	--	4
Covered	27	--
Ore, *Lower Mercer*	--	1

Jefferson Township.—The intervals from the Upper Mercer ore to other important members are given in the following section, taken along the road just south of the Mound School, in sections 19 and 20.

	Ft.	In.
Sandstone, massive	15	--
Shales and covered	21	--
Shales, dark, *Tionesta* coal horizon	3	--
Sandstone, massive	32	6
Ore, *Upper Mercer*	--	6
Sandstone, massive	20	--
Coal blossom, *Upper Mercer*	1	--
Clay	3	--
Sandstone, massive	13	--
Ore, *Lower Mercer*.		
Sandstone and covered	17	--

In Section 5, on the land of John H. Horton, the Upper Mercer ore was being mined, and the thickness of the bed was 10 inches. On the land of Evan Jenkins, Section 3, where the ore was also being mined the following relations were noted:

		Ft.	In.
Sandy clay and argillaceous sandstone		3	--
Shale		3	--
Ore	*Upper Mercer*	--	4
Sandstone		--	1
Ore		--	2
Cherty sandstone		--	1
Coal		--	1
Covered		13	3
Shale		4	--
Ore, *Sand Block*		--	6
Shale, blue, tough		6	--
Coal, *Upper Mercer*		1	2
Clay.			

South of the above along Black Fork and along the lower course of Hewitt Run, while the horizon is above drainage, the ore is wanting or replaced by heavy sandstones. The following record taken in Section 10 shows the general rock structure:

	Ft.	In.
Limestone, *Ferriferous*	5	--
Coal blossom, *Clarion*	3	--
Clay	3	--
Sandstone, massive	30	--

	Ft.	In.
Covered	10	--
Shales and covered	8	--
Shales, dark	5	--
Coal blossom, *Tionesta*	--	2
Clay shales, dark	1	--
Clay and clay shales, light	4	10
Sandstone, massive	7	--
Shales	3	--
Sandstone	17	6
Coal, *Upper Mercer* ore horizon	--	2
Clay shales	--	4
Sandstone, massive	25	--

Scioto Township.—In Section 36, Scioto Township, on the Anson Scurlock property the Upper Mercer ore was being mined by stripping where it was 9 inches thick. The upper part of a measurement on land of Andrew Yinger, in Section 13, shows the Upper Mercer ore and its relation to other strata:

	Ft.	In.
Shale	8	--
Ore, *Upper Mercer*, fossiliferous	--	5
Sandstone	--	8
Coal	--	6
Shale and covered	22	--
Coal, *Upper Mercer*	1	--
Shale and covered	12	--
Coal blossom	--	5
Clay shales	1	9
Ore, *Lower Mercer*, fossiliferous	--	3
Coal blossom	1	-

Franklin Township.—In Section 31, Franklin Township, on land of Edward Gahm and P. E. Lanhart, the ore measured 8 inches, but is reported to be 2 feet in local areas. In Section 30, on the property of Alexander Jones, the thickness of the ore seen was 8 inches. The Upper Mercer ore, varying in thickness from 4 to 8 inches, was seen at a number of places in sections 32, 33, and 34. A composite section on the land of Everett Rice, in Section 8, shows the ore and other members:

	Ft.	In.
Ore, *Upper Mercer*	--	8
Covered	12	--
Ore, *Sand Block*	--	3
Covered	45	--
Ore, *Lower Mercer*	--	4
Covered	82	--
Shales, gray	14	--
Shales, dark blue, sandy	4	--
Coal, *Vandusen*	--	10
Carbonaceous shale	1	--
Covered	2	--
Sandstone	10	--

The Upper Mercer ore was also seen at several places in Section 7, where it has about the same thickness as in the above section, and has been worked for the Jackson furnaces. A composite section taken along the ridge near the home of W. L. Brown, Section 3, shows the following relations:

		Ft.	In.
Limestone, *Ferriferous.*			
Covered		42	--
Ore, *Black Flint* horizon, reported thickness		--	4
Covered		43	--
Ore, *Upper Mercer*		--	3
Covered		78	--
Coal, cannel	*Lower Mercer*	--	8
Shale		--	6
Coal, cannel		--	10

Lick Township.—The Upper Mercer ore has been mined by benching along the outcrop quite extensively in the eastern part of Lick Township. It has good thickness and is rather persistent. In Section 26, on land of Harrison Kesinger, the measurements which follow were taken:

	Ft.	In.
Ore, *Black Flint* horizon, reported thickness	--	6
Covered	58	--
Ore, *Upper Mercer*	--	4
Covered	15	--
Sandstone, shaly	8	--
Coal, *Upper Mercer*	1	8
Covered.		

A composite section on the property of Michael Radcliff, in Section 23, shows the relation of several members as follows:

Limestone, *Ferriferous*, weathered blocks on summit of knob.	Ft.	In.
Covered	26	--
Coal, *Brookville*, reported thickness	1	8
Covered	15	--
Ore, *Black Flint*, horizon	--	4
Covered	40	8
Coal, reported thickness	1	4
Covered	10	--
Ore, *Upper Mercer*	--	4
Covered	20	8
Coal, *Upper Mercer*	1	--
Covered	48	--
Coal, *Lower Mercer*, cannel, reported thickness	1	3

In Section 22, on land of Madison Wykle, the rocks measured as follows:

	Ft.	In.
Ore, *Black Flint* horizon	--	6
Covered	48	--
Ore, *Upper Mercer*	--	5
Covered	25	--
Sandstone	8	--

		Ft.	In.
Shale		1	6
Coal	*Upper Mercer*	--	5
Clay		--	2
Coal		1	5
Covered		36	--
Coal, *Lower Mercer*, cannel nature		--	3

In Section 14, on land of George B. Wykle, a section showing the important members from the ore on the Black Flint horizon to the Lower Mercer limestones was obtained. The section following thus defines the position of the Upper Mercer ore:

	Ft.	In.
Sandstone	15	--
Ore, *Black Flint* horizon	--	6
Covered	15	--
Sandstone, calcareous, fossiliferous	1	--
Covered	3	--
Coal blossom, *Tionesta*	1	--
Clay, light	7	--
Shale	4	--
Sandstone	9	--
Coal blossom	1	--
Clay, sandy, bluish	2	--
Shale, sandy	5	--
Ore, *Upper Mercer*	--	2
Coal stain.		
Clay, light, sandy	2	--
Sandstone	8	8
Covered	5	--
Ore, kidney	--	2
Shale	6	8
Coal, *Upper Mercer*	1	1
Clay, good	3	--
Shale	9	11
Coal	--	4
Clay shale	2	8
Sandstone	3	--
Shale	3	--
Coal	--	9
Clay shale	2	--
Covered	5	3
Limestone, *Lower Mercer*, fossiliferous	1	--

Coal Township.—The Upper Mercer ore continues northward across Coal and Washington townships into Vinton County. A representative section showing the Upper Mercer ore and its stratigraphic position with reference to the Tionesta and Upper Mercer coals and the ore on the Black Flint horizon, was obtained on land of G. N. House, in Section 3, Coal Township. The rocks exposed and measured follow:

	Ft.	In.
Covered	15	--
Ore, *Black Flint* horizon	--	8

		Ft.	In.
Covered		25	--
Sandstone, shaly, calcareous, very fossiliferous		4	--
Shale, sandy, very fossiliferous		1	3
Shale, dark, very fossiliferous		--	4
Coal	*Tionesta*	1	2
Clay shale with thin coal bands		--	6
Coal		--	5
Clay, dark		--	11
Coal		--	10
Clay shale, dark		1	6
Covered		14	--
Ore, *Upper Mercer*		--	4
Sandstone, shaly		26	--
Shale		2	10
Coal, *Upper Mercer*		1	2
Covered.			

Along the road south of the abandoned Superior No. 2 mine, in Section 35, the measurement obtained shows the interval from the Upper Mercer ore to the Lower Mercer ore and limestone below. The following rocks were measured:

	Ft.	In.
Ore, *Upper Mercer*, thickness reported	--	5
Covered	35	--
Ore, sandy, *Lower Mercer*	--	4
Clay shales, light	1	8
Shales and covered	16	--
Limestone, *Lower Mercer*	1	--

Washington Township.—On land of W. R. Hamilton, Section 27, Washington Township, the ores have been mined by stripping. The section obtained shows the general relation of the Upper and Lower Mercer ores, and is given below:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Sandstone and covered	10	--
Covered	20	--
Coal blossom, *Upper Mercer*	1	--
Clay and covered	7	--
Sandstone and covered	10	--
Ore, *Lower Mercer*, fossiliferous	--	6

Milton Township.—In Milton Township the Upper Mercer ore was mined by benching first for the charcoal furnaces, and later for the modern coke furnaces. It is mined at present in a desultory way, but the amount produced is trifling. The section taken at the mine of the Wellston Colliery Company, in Section 5, Milton Township, shows the position of the Upper Mercer ore with reference to the Ferriferous limestone above and the Lower Mercer ore and Quakertown coal below. The section measured is as follows:

	Ft.	In.
Limestone, *Ferriferous*	3	--
Covered	62	--

	Ft.	In.
Ore, *Upper Mercer*	--	6
Covered	55	--
Ore, *Lower Mercer*	--	4
Shale	2	--
Sandstone, ferruginous	1	--
Covered	29	--
Top of shaft.		
Interval	78	--
Coal, *Quakertown*	2	6

The following composite section taken at the mine of the Elk Fork Coal Company, in Section 3, shows the Upper Mercer ore and other important members:

	Ft.	In.
Coal blossom, *Tionesta*	--	6
Clay, upper part dark	4	--
Covered	2	--
Sandstone	4	6
Covered	5	--
Sandstone	5	--
Ore, *Upper Mercer*	--	4
Shales	9	2
Coal, *Upper Mercer*	1	6
Sandstone, shaly	5	--
Top of shaft.		
Sandstone and covered	25	--
Limestone, *Lower Mercer*	1	--

The Upper Mercer ore is exposed along the small stream east of Mulga, in Section 3, and on the hill east of this, on the land of the Superior Colliery Company, in Section 2, the Clarion coal was opened. In Section 8, the measurements taken from the hollow near the abandoned Superior No. 6 mine to the hill west on land of George Woodrow, shows the Upper Mercer ore, the Clarion coal, and the Lower Mercer limestone. The record is given below:

		Ft.	In.
Coal	*Clarion*, reported thickness	1	2
Clay and bone coal		--	8
Coal		1	--
Clay-sulphur band		--	1
Coal		1	--
Covered		51	--
Coal blossom, *Tionesta*		1	--
Covered		31	--
Ore, *Upper Mercer*		--	4
Covered		35	--
Shale, part sandy		16	--
Covered		5	--
Limestone, *Lower Mercer*		--	10

The Upper Mercer ore here varies from 4 to 8 inches in thickness and has been mined by stripping. Along Mulga Run, in Section 10, the ore has also been mined, and the following section, taken on land of the Superior Colliery Company, shows the position of the ore and other important members:

	Ft.	In.
Sandstone, with finger coal. *Clarion* horizon	1	--
Shaly sandstone and covered	29	--
Coal, bony, cannel, *Tionesta*	1	--
Sandstone and covered	27	--
Ore, *Upper Mercer*	--	6
Shale	12	--
Coal, *Upper Mercer*, reported thickness	1	6

The ore where exposed along Mulga Run varies from 4 to 10 inches in thickness, but averages about 5 or 6 inches. The ore was exposed in the road near the bridge that crosses Little Raccoon Creek, in Section 15, and the rocks measured at this place are given below:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Shale	3	--
Coal blossom	--	2
Clay shale	--	6
Coal blossom	--	2
Clay shale	1	--
Shale, gray, sandy	6	6
Ore, *Sand Block*	--	4
Sandstone, ferruginous	1	--
Shale, carbonaceous, fissile, *Upper Mercer* coal horizon	2	--

The Upper Mercer ore and the associated strata were exposed on land of R. A. Fitzpatrick, east of Little Raccoon Creek, and in Section 16 along the road north of Middletown. Near Hogansville, along the road between sections 18 and 19, the Upper Mercer ore and the Lower Mercer and Ferriferous limestones were exposed and measured. The record follows:

		Ft.	In.
Limestone, flinty, *Ferriferous*		3	--
Shale, black, fissile		2	--
Coal	*Clarion*	1	2
Coal, bony		--	4
Clay		--	6
Coal		1	5
Clay		--	1
Coal		1	--
Clay and covered		13	--
Sandstone		9	--
Covered		10	--
Sandstone, soft		12	--
Shale		1	6
Ore, *Upper Mercer*		--	3
Clay, light		1	3
Sandstone		1	--
Covered		5	--
Ore, *Sand Block*		--	4

	Ft.	In.
Sandstone, ferruginous	--	8
Sandstone, soft	10	--
Covered	5	--
Sandstone	11	--
Clay, light	2	--
Sandstone, shaly	3	--
Sandstone, coarse-grained	5	6
Shale	1	6
Limestone, *Lower Mercer*, fossiliferous	1	--

Along the road just below the mouth of Coal Run, in Section 23, the Upper Mercer ore was exposed, and on the hill nearby the cannel coal was formerly mined. The following rocks and intervals were recorded:

	Ft.	In.
Coal, cannel, *Tionesta*, thickness reported	2	--
Sandstone and covered	32	--
Sandstone, coarse-grained	2	--
Shale, gray	3	--
Ore, *Upper Mercer*, fossiliferous	--	4

The Upper Mercer ore goes below drainage in the Little Raccoon Valley, in the southern part of Section 23, but it is exposed along the headwaters of Flint and Tarcamp runs.

Bloomfield Township.—Along the headwaters of Dickason Run, especially in the vicinity of Ridgeland, in Bloomfield Township, the Upper Mercer ore is again above drainage. It was mined by stripping here during the days of the charcoal furnaces, but the bed is not as thick or persistent as the ore on the Black Flint horizon.

Economic Value of Upper Mercer Limestone and Associated Coals and Shales

The Upper Mercer limestone is present only in a few localities in Jackson County, where the bed is represented by dark, nodular limestone and chert, only a few inches in thickness. The stratum is of interest only for its stratigraphic value, for it is of great aid in correlating the thin coals found in the general horizon. In some localities there is found a thin coal bed only a few inches below the limestone or ore, but this seldom reaches 1 foot in thickness, and is usually only a smut streak. In some localities in eastern Coal and Lick, and western Milton townships, there is found a thin coal bed about 10 feet above the horizon of the Upper Mercer ore. The stratum is usually about 1 foot in thickness, but at a few places it is from 1 foot 4 inches to 1 foot 6 inches. It has been prospected, but has not been mined even by stripping. The coal is of good quality and has a blocky structure.

Shale deposits, which are often many feet in thickness, and which are suitable for ceramic ware, are found in some localities in the interval from the Lower to the Upper Mercer limestone. In some regions the interval is composed mainly of massive sandstone. These shale deposits are an asset only when favorably located with regard to plant site, shipping facilities, fuel and water supply, etc.

Economic Value of Upper Mercer Ore

Next to the Ferriferous, the Upper Mercer ore was the main reliance for the ore supply of the charcoal furnaces. For the coke furnaces it now stands third, ranking below the Jackson Sand Block ore and the Ferriferous. The thickness of the deposit varies from a few inches to about 2 feet, but that usually observed is from 5 to 10 inches. Under heavy cover the ore is a ferrous carbonate, the usual coal formation type, but along the outcrop it is a ferric oxide with more or less combined water. The carbonate ore was not desired for charcoal furnace use, and even the gray or partially weathered material was often condemned. On this account, and owing to ease in mining, the stratum was worked only along the outcrop or under shallow cover: hence the main ore body yet remains in the hills. The mining at present is done by stripping with pick and shovel, with plow and scraper, or, where the strata above are hard shales or sandstones, with explosives and scraper. No drift mines are operated in Jackson County for the Upper Mercer ore.

The iron content of the ore compares favorably to that of the siliceous Lake ores, while the phosphorus and manganese are well proportioned for foundry pig. The general character of the Upper Mercer ore is shown by the following analysis, kindly furnished by the Jackson Iron & Steel Co.:

Iron, Fe	41.14 per cent.
Phosphorus, P	.344
Silica, SiO_2	22.10
Alumina, Al_2O_3	4.92
Manganese, Mn	.78
Lime, CaO	none
Magnesia, MgO	none
Moisture	6.80

The Star Furnace Company reports the Upper Mercer ore, which is mined on the Scurlock property south of Jackson, to contain from 51.10 to 54.30 per cent. of iron. An analysis of the Upper Mercer ore from the vicinity of Jackson is as follows:[1]

Specific gravity	2.774
Combined water	11.30
Siliceous matter	9.16
Sesquioxide of iron	74.63
Alumina	1.20
Manganese oxide	1.15
Carbonate of lime	0.52

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[1] Geol. Surv. Ohio, Report of Progress, 1870, p. 150.

Carbonate of magnesia	0.76
Phosphoric acid	0.83
Sulphur	trace
Total	99.55
Percentage of metallic iron	52.24

The ore smelts easily as the structure is porous, thus allowing the reducing gases to permeate the mass. Even when smelted in the coke furnaces the iron carbonizes somewhat similarly to that made by the old charcoal furnaces. The iron is soft and tough, hence it is a standard iron for all foundry work. When all points are considered, these ores surpass the siliceous Lake ores in value, and should be more extensively used.

TIONESTA OR NO. 3b COAL AND CLAY

The Tionesta or No. 3b coal is very unsteady in Jackson County, which is also true of the member in Lawrence and Scioto counties. The bed has sufficient thickness for regular drift mining in only a few localities, and in these the areas are small. The horizon is more often marked by the black carbonaceous shales and the light siliceous clay, that form the roof and floor of the bed, than by coal. The bed is variable in structure also; for in one hill it may be made up of only one coal bench, but in the next this may be broken up into several thin benches, with shales or clays intervening. In southern Jackson County, especially near Monroe Furnace, the deposit is made up of bituminous coal, while on Coal Run, in Milton Township, it is a true cannel coal, yet, where it passes into Vinton County, in the region of the Jackman School, in Richland Township, it is again bituminous in character. Although the member is very persistent, the bed is one of the most variable in character in the lower Coal Measures. The shales and sandstones above the Tionesta coal are usually remarkably fossiliferous, and this feature is a valuable aid in the correlation of this and other members. In Jackson County the member is best developed near Monroe Furnace, in Jefferson Township, and on Coal Run, in Milton, where it has been mined by drifting, although at other places it is mined by stripping for local use.

In the southeastern part of Hamilton Township the blossom of the Tionesta coal is found close to the summit of the main ridge near the Oak Grove School. The horizon is found high on the hills and ridges in western Jefferson, and, owing to the dip eastward, goes under cover near the eastern boundary. In Franklin Township the coal is seldom present, as the interval is largely made up of massive sandstone.

In southern Bloomfield Township the member goes below drainage in the Symmes Creek Valley, and in the northern part along the course of Dickason Run west of Keystone Furnace. The Tionesta coal is found along the main ridges in the eastern half of Lick Township, and the same is true of Coal Township. In Washington Township the western outcrop of the member is marked by thin coal and black shales on the highest knobs and ridges east of the Cincinnati, Hamilton & Dayton Railway. In northern Milton Township the bed goes below drainage near the Lincoln School. South of this along Mulga Run it disappears in the hills east of the stream, and on Rich Run the blossom of the coal passes below drainage in the southeastern part of Section 11. On Coal Run the member, here represented by cannel coal, goes under cover just west of the mine of the Mohawk Coal Company. The bed was seen near the road level at the mouth of Buffer Run and near Buckeye Furnace, while south of this it was last observed near the Milton-Bloomfield line.

Stratigraphy and Extent

The interval from the Tionesta coal to the overlying Ferriferous limestone in Jefferson Township varies from 50 to 75 feet. The average interval however is about 60 feet. Much the same conditions were found in eastern Franklin and Lick Townships and in western Bloomfield. In Milton Township, along the courses of Little Raccoon Creek and its tributaries, the interval is considerably shortened, as it varies from 35 to 55 feet, but averages close to 45 feet. From all the measurements made in Jackson County the average interval from the Tionesta coal to the Ferriferous limestone is 55 feet; to the Black Flint siliceous limestone and ore 22 feet, and to the underlying Upper Mercer ore 29 feet.

Jefferson Township.—Near the head of Monroe Hollow, in Section 29, Jefferson Township, the Tionesta coal was formerly mined for railroad shipment, but at present the workings are abandoned, although the productive area is not exhausted. In Section 30, on the property of A. Kelley, the structure of the Tionesta coal in a drift mine is as follows:

		Ft.	In.
Shale, black, tough		11	--
Coal, good	*Tionesta*	1	3
Coal, bony		--	6
Coal, good		2	2
Coal, cannel		--	3

In the southwestern corner of Section 29, on land of Emerson Coon, the following structure was seen in a bench mine:

		Ft.	In.
Shale, dark, sandy, carbonaceous		2	--
Coal, good	*Tionesta*	--	2
Coal, bone		--	9
Coal, somewhat bony		--	10
Coal, good		1	2

East of Monroe Furnace the Tionesta coal is wanting or thin. Along Lefthand Fork the Tionesta horizon goes under cover near the old Cambria Furnace.

The Tionesta coal is thin or wanting along Black Fork from the Baltimore & Ohio Southwestern Railroad north. In the exposures noted along Hewitt Run the Tionesta bed was represented at most by only a few inches of coal. North of Hewitt Run, where exposed, the Tionesta coal is represented mainly by the associated black shales, light clay, and sandstone.

Madison Township.—In Madison Township, on land of George Drummonds, in Section 6, the Tionesta coal has been benched in the bed of Black Fork near the road bridge. Mr. Drummonds reports the total thickness of coal and partings about 4 feet. The aneroid measurement from the coal to the Ferriferous limestone was 64 feet.

Franklin Township.—In Franklin Township the Tionesta coal is wanting mainly as it is replaced by massive sandstones, but at a few places the black shales that mark the horizon were seen.

Lick Township.—In eastern Lick Township the Tionesta member is better represented, but it seldom thickens to over 1 foot 6 inches. A section measured along the road between sections 35 and 36 and north of the Jackson-Keystone Pike shows the following members:

	Ft.	In.
Ore, *Black Flint* horizon	--	6
Shale, sandy	15	6
Shale, gray	7	--
Shale, dark	2	--
Coal blossom, *Tionesta*	1	--

The rocks exposed along the road in the northeastern part of Section 23 show the following relation of the Tionesta coal to the ore on the Black Flint horizon:

		Ft.	In.
Ore	*Black Flint* horizon	--	4
Shale		2	--
Ore		--	6
Shale		1	2
Ore		--	4
Shale, very fossiliferous		14	--
Coal blossom, *Tionesta*		1	--

Along the road near the home of George B. Wykle, Section 15, an excellent record was obtained, for it shows all the important members from the Lower Mercer limestone to the ore on the Black Flint horizon. The section shows about the normal intervals separating the various members and is as follows:

	Ft.	In.
Ore, *Black Flint* horizon	--	6
Covered	15	--
Sandstone, calcareous, very fossiliferous	1	--

	Ft.	In.
Covered	3	--
Coal blossom, *Tionesta*	1	--
Clay, light	7	--
Shale	4	--
Sandstone	9	--
Coal blossom	1	--
Clay, bluish, siliceous	2	--
Shales, sandy	5	--
Ore, *Upper Mercer*	--	2
Coal stain	--	1
Clay, light, siliceous	2	--
Sandstone, light at top	8	8
Covered	5	--
Ore, *Sand Block*	--	2
Shales	6	8
Coal, *Upper Mercer*	1	1
Clay, good	3	--
Shales	9	11
Coal	--	4
Clay shale	2	8
Sandstone	3	--
Shale	3	--
Coal	--	9
Clay shale	2	--
Covered	5	3
Limestone, *Lower Mercer*	1	--

Coal Township.—The Tionesta coal is found well towards the summits of the knobs and ridges in the eastern part of Coal Township, but the bed seldom exceeds 1 foot in thickness, while in most of the area it is represented only by the siliceous clay and dark shales. In a small area east of Coalton the member has thickened locally, and has been prospected on land of G. N. House, in Section 3. The structure of the bed is shown in the following section:

		Ft.	In.
Shale, dark, very fossiliferous		--	4
Coal	*Tionesta*	1	2
Clay shale with thin coal bands		--	6
Coal		--	5
Clay, dark		--	11
Coal		--	10

Washington Township.—In Washington Township the Tionesta coal is found on the high knobs and ridges as far west as the Cincinnati, Hamilton & Dayton Railway. The bed is quite persistent, but at no place was it found sufficiently thick for mining; hence a few sections only will be given in order to illustrate its relations to other members. The upper part of a record taken on land of E. C. Wallace, in Section 23, is as follows:

	Ft.	In.
Ore, *Black Flint* horizon	--	6
Shale, very fossiliferous	10	--
Coal blossom, *Tionesta*	--	6

The Tionesta coal extends northward into Vinton County, and near the Jackman School, in Section 34, Richland Township, the bed has good thickness. The local fuel supply is obtained from it by drift mining. A section taken there is given below in order to show the general character of the member and the interval to the ore on the Black Flint horizon:

	Ft.	In.
Ore, *Black Flint* horizon	--	8
Shale	5	--
Shale and covered	19	--
Shale, very fossiliferous	4	--
Coal, *Tionesta*	5	1

Milton Township.—In Milton Township the Tionesta coal is very unsteady and variable in character. In most of the area above drainage the bed is thin and bony, but on Coal Run and vicinity it assumes the phase of a cannel coal, and thickens to about 2 feet. The member will be traced southward across the township. Near the mine of the Minglewood Coal Company, in Section 34, the following measurements were obtained:

	Ft.	In.
Flint, *Black Flint*	1	--
Covered	18	6
Coal, *Tionesta*	1	4

The Tionesta coal goes below drainage on Mulga Run near old Lincoln Furnace. In Section 3, north of the mine of the Elk Fork Coal Company, the thin blossom of the Tionesta coal was exposed. West of the abandoned Superior No. 6 mine, in Section 8, the following record shows the general relation of the important members:

	Ft.	In.
Ore, *Ferriferous.*		
Shale, black	3	--
Coal and partings, *Clarion*	3	11
Covered	51	--
Coal blossom, *Tionesta*	1	--

Near the mouth of Mulga Run, in Section 10, the Tionesta coal assumes the cannel phase, but measures only 6 inches in thickness. On Rich Run, in Section 11, on land of the Superior Colliery Company, the record given below was obtained:

	Ft.	In.
Coal blossom, *Tionesta*, cannel	1	--
Covered	18	--
Ore, *Upper Mercer*	--	7

The cannel coal has been mined on Rich Creek on land of J. W. Phillips, and is reported to be 1 foot 8 inches in thickness. The member was seen on the outcrop at several places, and goes below drainage in the northeastern part of Section 14. The record measured in the northern part of Section 15, on land of James E. Goddard, shows the following members:

	Ft.	In.
Coal blossom, *Tionesta*	1	--
Clay, light	4	--
Sandstone, light	5	--
Sandstone	9	--
Ore, *Upper Mercer*	--	8

Along Coal Run, in the southern part of Section 14, the Tionesta bed, here a hard cannel coal, was worked at one time for railroad shipment, but at present it furnishes only small quantities of fuel for local domestic use. From outcrop indications, there is an area of about two square miles here in which the coal exceeds 1 foot 6 inches in thickness, and, since the original mining was confined to short entry work, only a small part of the total area is exhausted. The coal is a true cannel, hard, lustrous, and moderately pure. The main coal bench usually contains a few inches of bone coal in the upper part, but this is not constant. A section taken on the land of the Superior Colliery Company shows the general structure as follows:

		Ft.	In.
Shale, black, tough		1	6
Coal, cannel	*Tionesta*	--	1½
Coal, bituminous		--	3
Clay shale, dark		1	4
Coal, cannel, bony		--	6
Coal, cannel, good		2	6

The coal of good quality in the lower bench in this locality is reported to vary from 1 foot 2 inches to 2 feet 6 inches, but to average about 2 feet. The Tionesta coal in this locality lies from 40 to 50 feet below the Clarion coal, and from 20 to 30 feet above the Upper Mercer ore.

The cannel coal was exposed for measurement on land of J. W. O'Neil, in Section 23, and the record obtained follows:

		Ft.	In.
Shale, dark, tough		1	--
Coal, cannel	*Tionesta*	--	1½
Coal, bituminous		--	2½
Clay shale, dark		1	3
Coal, cannel, bony		--	8
Coal, cannel, good		1	10
Coal, cannel, bony		--	4

The bony part of the main coal bench is reported to be somewhat thinner in places in the mine. In the southeastern part of the section the cannel coal is exposed along the roadside, where the interval to the Clarion measured as follows:

		Ft.	In.
Coal	*Clarion*	1	3
Clay with coal bands		--	8
Coal		1	5
Clay		--	1
Coal		1	3

	Ft.	In.
Clay	1	--
Covered	7	--
Sandstone	5	--
Covered	15	--
Shale and shaly sandstone	7	--
Shale, dark	3	--
Coal blossom, *Tionesta*	1	--

The coal has been stripped for local use and is reported thicker under cover. The blossom of the Tionesta coal was noticed at a few places in Section 22, but the surface indications point to the bed being thin and somewhat bony. In Section 21 where observed the member is a bituminous coal, with associated bone and highly carbonaceous shales. Along Little Raccoon Creek south of Buckeye Furnace, the Tionesta member is represented by a thin coal bed, seldom over a few inches in thickness, and by black carbonaceous shale. It goes below drainage a short distance south of the Milton-Bloomfield line.

Bloomfield Township.—The Tionesta coal is well above drainage in western Bloomfield Township along the upper course of Dickason Run, but it seldom thickens sufficiently for mining, even by stripping.

Economic Value of Tionesta Coal

The Tionesta coal adds but little to the fuel wealth of Jackson County, as the known productive areas above drainage are confined to a few sections in southwestern Jefferson Township and to the small field on Coal Run, and in its vicinity in Milton Township. In the former locality the bed has good thickness, and the mining conditions are excellent, as the roof is a tough shale, while the floor is either a siliceous clay or an argillaceous sandstone. In this locality the member is usually made up of two or more coal benches, separated by shales or bone coals. The coal in the main benches is an oily free-burning fuel, moderately low in sulphur and ash, thus serving well for general domestic purposes.

In the Coal Run field the Tionesta member is made up of two coal benches, separated by a foot or more of clay shale, which in places contains thin coal layers. The upper bench, usually from 4 to 6 inches in thickness, is part cannel and part bituminous coal. The lower bench, which is the main coal block, varies in thickness from 1 foot to 2 feet 6 inches. The upper few inches of this bench are usually bony, and in places a few inches of bone coal are also found in the lower part. The shales above are quite tough; hence they form a good roof for mining, while the floor materials are siliceous clays or clay shales. In mining the coal the cutting is done in the bituminous part of the upper bench or in the clay shale partings, then the lower bench is loosened by wedging or shooting. The coal in the lower bench is broken into blocks by vertical joint planes, which thus aid in its mining. The bone coal is then split off, and either thrown back in the mine or kept separate from the good coal. The coal burns freely, with a luminous clear blaze, and compares favorably with the average cannel coal on the market with regard to ash and sulphur constituents. It burns to a light powdery ash that does not clinker, to any considerable extent, under ordinary conditions. An analysis of the coal shows the following composition:[1]

Cannel coal of Milton Township (Lord). Sampled by C. N. Brown.

Moisture	2.32
Volatile matter	44.52
Fixed carbon	41.13
Ash	12.03
Total	100.00
Sulphur	0.84

An analysis of the cannel coal from Coal Run, in Milton Township, made by Paul Overmeyer, is as follows:

Moisture	1.35
Volatile matter	51.70
Fixed carbon	33.14
Ash	13.81
Total	100.00
Sulphur	1.38

The main ash constituents were as given below:

Silica	6.10
Alumina	4.02
Ferric oxide	1.64
Lime	0.60
Magnesia	0.59

Economic Value of Tionesta Clay

The Tionesta clay is well developed over a much larger area than the coal, but the best of this is confined to southern Jefferson Township. The deposit varies in thickness from 1 to as much as 15 feet, but it has an average thickness of 5 or 6 feet. The stratum is everywhere siliceous in character. It varies from a sandy clay in the upper part to a ganister, or a fine-grained clay-bond sandstone in the lower, both of which are light-colored, and quite free from detrimental fluxing materials. The deposit is of value for ceramic purposes, as the clay is suitable for building and second-grade fire brick, for stoneware, and for sewer pipe. The ganister may be utilized for refractory ware where an acid material is desired. If the clay is mined in conjunction with the coal, the cost of winning each is considerably lowered. In some localities the coal bed is sufficiently thick to furnish fuel for the complete manufacture of several feet of clay, or ganister into ware. The value of the clay or coal, considered alone, is small, but the utilization of both would make the interval economically important.

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[1] Geol. Surv. Ohio, Vol. V, p. 1032.

HOMEWOOD OR TIONESTA SANDSTONE

The next member in ascending order is the Homewood or Tionesta sandstone, which forms the upper bed of the Pottsville formation. The sandstone above the Tionesta coal in Jackson County is very unsteady and variable in thickness. In many localities the interval between the Tionesta and Brookville coals is made up of shales, or of shales with irregular sandstone layers, while in other areas the interval from the former bed to the Clarion coal is composed of massive sandstone with no apparent break or line of separation. At other places in this interval there may be several sandstone strata separated by shales, or by shales and thin coals, but with no mark of distinction sufficiently clear to place with any degree of certainty the line separating the Homewood sandstone below from the Hecla member above. The Homewood sandstone is not a special feature of the stratigraphy of Jackson County.

Along the outcrop the Homewood sandstone is usually stained yellow with iron compounds, and also shows more or less clay material. In general it is too impure for glass sand, but in some localities, especially under heavy cover, the stone by proper crushing and washing may produce a sand of fair quality. It is too soft and fragile for building stone or road ballast. The Homewood sandstone does not add materially to the mineral wealth of the county.

BLACK FLINT HORIZON

Closely associated with the Brookville coal, in parts of Jackson and Vinton counties, there are found deposits of black flint, calcareous shales and kidney ores. When both the flint and coal are present the former lies just below the coal. This condition is found in certain localities in northern Jackson and southern Vinton counties, but the flint is much less persistent than the coal. East of Coalton and Jackson the flint and coal are seldom present, but a kidney ore is found which marks the horizon, and which has been mined for the charcoal and coke furnaces. The flint and calcareous shales are fossiliferous, but no specimens were observed in the few exposures of ore examined. The fossils have not been studied; so their bearing on the position of the bed is not known.

The shales and shaly sandstones found above the Tionesta coal are of special interest also, as they are remarkably fossiliferous in many localities in Jackson County. These beds often make up most of the interval from the Tionesta to the Brookville coals, and are directly related to the black flint and to the ore found just below it. The thickness of the fossiliferous shales is 6 feet at Monroe Furnace; 2 or 3 feet at Cambria Furnace; 14 feet in Section 23, Lick Township; 6 feet in Section 3, Coal Township; 4 feet in Section 8, Bloomfield Township, and 10 feet in Section 23, Washington Township. The beds were seen at other places also. This fossil zone is quite persistent, and is thus a valuable aid in determining the stratigraphic relations of the thin coals in the upper part of the Pottsville and the lower part of the Allegheny formations. The fossils are of marine origin, very abundant, and quite well preserved, hence the beds afford rare opportunities for collecting the fauna that flourished during the latter part of Pottsville time. These beds extend southward into Scioto and Lawrence counties and northward into Vinton. In the latter, near the Jackman School, in Section 34, Richland Township, the fossil zone is several feet in thickness, and the fossils are easily obtained from the shales; further, the Tionesta coal has good volume. In general the types represented are those characteristic of the Mercer limestones below.

The shales, and especially the shaly sandstones, are quite calcareous, and in some localities, when unweathered, have the general appearance of impure limestone, and in fact may be taken for such. The calcium carbonate, in a sample taken from above the coal where opened on the G. N. House property, in Section 3, Coal Township, and analyzed by Paul Overmeyer, was 34 per cent. In a general way these beds represent similar conditions to those that existed during the deposition of the Lower and Upper Mercer limestones below. They are directly related to the black flint, which appears to represent the final deposit. The fossils and percentage of calcium carbonate indicate conditions favorable for limestone formation, but which were modified by the high rate of deposition of clastic sediments, so the resultant products were calcareous shales and sandstones. They show a shallow water stage at the close of the swamp period during which the Tionesta coal was laid down, and the relation of coal to calcareous shales and sandstones here agrees in a general way with that existing between the Clarion coal and Ferriferous limestone, or the Wilgus coal and Cambridge limestone.

Owing to their relations to the Tionesta and Brookville coals, the fossiliferous shales, kidney ores, and black flint are here placed in the Pottsville formation with some degree of confidence. In this report the flint and ore on the horizon described are designated Black Flint, in order that the deposits may be followed without confusion. This term is not to be considered the true name of the member in the geological nomenclature of Ohio rocks, for the correlation of the flint and ore with well recognized members in central Ohio has not been established. However, this work is being done by Clara G. Mark.

The interval of the flint and ores from the Ferriferous limestone above varies from 15 to 55 feet, but it is on the average about 31 feet, while the interval to the Tionesta coal below is approximately 21 feet, although it varies from 10 to 35 feet.

The fossiliferous shales, kidney ores, and black flint on this general horizon, or in the interval from the Tionesta to the Brookville coals, will be traced across the county in order to show their extent and relations to other beds in the Pottsville and in the Allegheny formations.

Jefferson Township. — A section was made at Monroe Furnace giving the following strata:[1]

	Ft.	In.
Soil.		
Brown clay with a layer of kidney ore	8	--
Limonite ore	--	8
Ferriferous limestone	5	--
Dark gray shale	1	--
Coal, (reported)	3	--
Not exposed	53	--
Sandstone containing iron ore and *Spiriferae* and *Producti*	6	--
Clay shale	4	--
Coal, with two thin shaly partings	3	--
Not seen	60	--
Block ore	--	7
Clay shale	4	--
Coal, (reported)	1	6

The coal found 4 feet below the calcareous, fossiliferous sandstone in the above section is the Tionesta. These fossiliferous shales are also exposed south of this in Slab Hollow. In Section 30, on the property of A. Kelley, these highly fossiliferous shales are also found only a short interval above the Tionesta coal. Near old Cambria Furnace, in Section 36, this bed of fossiliferous shale, with layers of ore above, are exposed along the bed of Lefthand Fork.

Lick Township.—In the southern part of Jackson County the horizon of the black flint and ore is generally taken by heavy sandstones, but even in the few localities where shales were present neither the flint nor the ore was seen. The ore appears in the eastern part of Lick Township, where it has been mined for both the charcoal and coke furnaces. The bed here is fairly persistent and has good thickness for a native ore. The following measurements were made of the rocks exposed along the road north of the Jackson-Keystone pike and along the line of sections 35 and 36:

	Ft.	In.
Limestone, *Ferriferous*, weathered	4	--
Coal blossom, *Clarion*	4	6
Clay shale, dark, sandy	4	--
Sandstone, massive	17	--

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[1] Geol. Surv. of Ohio, Report of Progress, 1870, p. 159.

	Ft.	In.
Sandstone and covered	9	--
Ore, *Black Flint* horizon	--	6

A section measured from the Globe shaft, in Section 28, to the hill north, shows the interval from the Sharon coal to the ore on the Black Flint horizon. The section as recorded is as follows:

	Ft.	In.
Ore, *Black Flint* horizon.		
Covered	120	--
Coal, *Lower Mercer*	1	--
Covered	34	--
Top of shaft.		
Interval	110	--
Coal, *Sharon*	3	6

By adding to this the thickness of the Sharon conglomerate which lies below, the total thickness of the Pottsville formation is obtained. A carefully measured section which shows the important members between the ore on the Black Flint horizon and the Lower Mercer limestone was obtained on land of George B. Wykle, in Section 24. The record follows:

	Ft.	In.
Ore, *Black Flint* horizon	--	6
Covered	15	--
Sandstone, calcareous, very fossiliferous	1	--
Covered	3	--
Coal blossom, *Tionesta*	1	--
Clay, light	7	--
Shale	4	--
Sandstone	9	--
Coal blossom	1	--
Clay, sandy	2	--
Shale, sandy	5	--
Ore, *Upper Mercer*	--	2
Coal stain.		
Clay, light sandy	2	--
Sandstone	8	8
Covered	5	--
Ore, *Sand Block*	--	2
Shale	6	8
Coal, *Upper Mercer*	1	1
Clay	3	--
Shale	9	11
Coal	--	4
Clay shale	2	8
Sandstone	3	--
Shale	3	--
Coal	--	9
Clay shale	2	--
Covered	5	3
Limestone, *Lower Mercer*	1	--

The upper part of a section measured along the road in the northeastern part of Section 23 shows the ore on the Black Flint horizon to be broken up into three benches. The record taken is as given below:

		Ft.	In.
Ore	*Black Flint* horizon	--	4
Shale		2	--
Ore		--	6
Shale		1	2
Ore		--	4

This ore which is quite persistent in eastern Lick Township was mined at many places. The member varies in thickness and structure for it is often broken into two or more layers with shales intervening. The flint was not seen in this township, but a thin coal bed varying from a few inches to one foot or more in thickness was noticed in a few localities. The coal here lies from 5 to 15 feet above the ore, but is probably correlative with the coal above the flint in northern Jackson and southern Vinton counties.

Coal Township.—The flint as well as the ore is present in a few places in the southern part of Coal Township, although both are rather unsteady. A section taken on land of G. N. House, in Section 3, shows the following relations:

		Ft.	In.
Ore, *Black Flint* horizon		--	8
Covered		25	--
Sandstone, shaly, very fossiliferous		4	--
Shale, sandy, very fossiliferous		1	3
Shale, dark, very fossiliferous		--	4
Coal	*Tionesta*	1	2
Clay shale with thin coal bands		--	6
Coal		--	5
Clay, dark		--	11
Coal		--	10

On land of J. J. Bennett, in the central part of Section 3, loose pieces of black flint were observed on the summit of the high ridge, but the bed was not exposed for measurement. Along the ridge south of this the ore has been mined by stripping. In the northern part of the township the ore has been mined in a few localities, but no records were obtained.

Washington Township.—In Washington Township both flint and ore are present, but the Brookville coal above was not seen. A section embracing practically the entire thickness of the Pottsville was obtained from Glen Nell to the hill near the Town House, in Section 21, where the Black Flint is exposed. The record follows:

	Ft.	In.
Flint, black, *Black Flint*	1	--
Shale and covered	18	--

	Ft.	In.
Shale	3	--
Coal blossom, *Tionesta*	1	--
Clay, sandy	2	--
Sandstone	37	--
Covered	14	--
Shale, dark	6	--
Coal, *Upper Mercer*	1	--
Shale and covered	3	--
Shale, sandy	8	--
Covered	4	--
Sandstone	12	--
Ore, *Lower Mercer*	--	2
Covered	75	--
Sandstone	5	--
Coal, irregular	--	6
Sandstone	3	2
Sandstone and shale, irregular	3	6
Coal, *Quakertown*	2	6
Covered	61	--
Sandstone, coarse-grained	12	--
Ore, *Sharon*	--	7
Shale	--	4
Coal, *Sharon*	3	1
Covered	3	--
Conglomerate, *Sharon*	15	--

Here the interval from the Sharon coal to the Black Flint is 273 feet, while at the Globe shaft the interval from the coal to the ore on the Black Flint horizon is 265 feet.

The Black Flint is exposed in the road in Section 22 just north of the Town House. Here it is quite fossiliferous and affords good collecting. It was also observed on the knob near the forks of the road. In Section 23, on the E. C. Wallace property, the ore has been mined by stripping. The upper part of a section obtained there follows:

	Ft.	In.
Ore, *Black Flint* horizon	--	6
Shales, very fossiliferous	10	--
Coal blossom, *Tionesta*	--	6

Weathered flint and calcareous shales were seen on the summit of the high knob on land of Michael O'Brien, in Section 15, and the blossom of the Tionesta coal was exposed about 20 feet below. The flint is also present on the summit of the knob on the Richland Furnace land, in the eastern part of Section 9, but it was not exposed sufficiently for measurement.

Richland Township, Vinton County.—The flint thickens northward where it passes into Vinton County; hence a few sections will be given from Richland and Clinton townships. The following rocks were exposed along the road on the high knob in the northeastern part of Section 32, Richland Township, Vinton County:

	Ft.	In
Flint, black, fossiliferous, *Black Flint*	1	--
Covered	3	--
Sandstone	6	--
Shale and covered	10	--
Coal blossom, *Tionesta*	2	--

Near the Jackman School, in Section 34, the ore was mined by stripping for the charcoal furnaces, and the Tionesta coal below, which has excellent volume, is mined for local use. The section obtained follows:

	Ft.	In.
Ore, *Black Flint* horizon	--	8
Shale	5	--
Shale and covered	19	--
Shale, very fossiliferous	4	--
Coal, *Tionesta*	5	1

Clinton Township, Vinton County.—In Clinton Township, east of Hamden, the Black Flint with the Brookville coal above is also found in some localities. In Section 23, Clinton Township, on the Tarr farm, the following relations were found:

		Ft.	In.
Coal, good	*Brookville*	1	6
Clay		--	3
Coal, somewhat bony		1	1
Bone coal and shale		--	7
Clay and covered		1	6
Flint, black, fossiliferous, *Black Flint*		1	10

A composite section taken along the road near the line of sections 23 and 24 is as follows:

		Ft.	In.
Limestone, *Ferriferous*		4	--
Covered		9	--
Sandstone, light		10	--
Coal blossom, *Brookville*		4	--
Shales, calcareous, hard	*Black Flint*	1	--
Flint		--	4

Milton Township, Jackson County.—The calcareous shales and black flint are found in a few localities in the northern part of Milton Township, while the Brookville coal is fairly persistent. The section obtained at the mines of the Minglewood Coal Company, in Section 34, Milton Township, shows the stratigraphic relation found here for the Black Flint and the Brookville, Clarion and Tionesta coals. The record obtained follows:

	Ft.	In.
Coal blossom, *Clarion*	3	6
Covered	9	--
Coal blossom, *Brookville*	2	--

	Ft.	In.
Covered	1	--
Flint, black, fossiliferous, *Black Flint*	1	--
Covered	18	6
Coal blossom, *Tionesta*	1	--

From surface exposures noted south of Mulga Run near Lincoln Furnace, the flint passes into calcareous shales and these become wanting, while farther south the ore appears, but it is quite unsteady, as the interval is usually made up of massive sandstones. The member is not well represented in southern Milton Township, but the Brookville coal is occasionally seen.

Bloomfield Township.—While the ore on the Black Flint horizon is rather persistent in northwestern Bloomfield Township, where it was formerly mined by stripping for the charcoal furnaces, the flint was not observed, and the Brookville coal above is poorly represented. East of Ridgeland, in Section 8, Bloomfield Township, on land of Albert W. Lackey, the ores on the Black Flint and Upper Mercer horizons have been mined, and flinty Ferriferous limestone was seen on the hill above. The ore on the Black Flint horizon is reported to vary from 4 to 10 inches in thickness, and to average about 8 inches. In the western part of the same section, on the lands of Harriet A. and W. L. Burris, the ore, formerly mined quite extensively by stripping is reported to vary from 3 to 15 inches in thickness, and to average about 10 inches. The Tionesta and Upper Mercer coals are exposed below the ore and the latter is mined for local use. The section taken is given below:

		Ft.	In.
Limestone, *Ferriferous*		4	--
Covered		49	--
Ore, *Black Flint* horizon		--	10
Covered		8	--
Shale, gray		3	--
Shale, sandy, fossiliferous		4	--
Shale, dark		4	--
Sandstone, dark		--	4
Shale, carbonaceous, fissile		2	--
Coal, good	*Tionesta*, reported thickness	--	10
Clay		--	10
Coal, good		1	2
Covered		8	2
Shale, sandy		9	--
Shale		--	4
Coal, *Upper Mercer*		1	11

Economic Value

The flint and calcareous shales on the Black Flint horizon have no practical value, but are of interest mainly for their stratigraphic relation to the Brookville coal and for the fauna represented, which at present has been but little studied. The ore is of some economic value as the bed furnished a part of the ore supply for the charcoal furnaces originally in operation in the Jackson and Wellston regions, and it has also contributed some ore for the present coke furnaces. In thickness the bed varies from a few inches to 2 feet, but averages about 8 or 10 inches. In some localities the member is divided into two or even three ore benches, separated by shales, but in most of the area only one bench is present. Along the outcrop, where the bed has been affected by weathering, the ore belongs to the hydrated oxide type, but under heavy cover it is a carbonate of the usual gray or bluish-gray color. The weathered ore, which is soft, smelted readily in the charcoal furnaces. The ore has been mined entirely by stripping along the outcrop; hence the main ore body has scarcely been touched. Since the introduction of the Lake ores the native ores have been neglected, although they may be used to good advantage for the siliceous part of the burden. The ore is not of wide extent as the bed is confined mainly to northeastern Franklin, northwestern Bloomfield, eastern Lick, and western Milton townships, although it has also been mined at a few places in eastern Coal and Washington townships. An analysis of the "kidney ore" from the Black Flint horizon is as follows:[1]

Specific gravity	3.551
Combined water	1.24
Siliceous matter	7.54
Sesquioxide of iron	9.66
Carbonate of protoxide of iron	73.38
Alumina	.24
Manganese oxide	2.00
Carbonate of lime	2.50
Carbonate of magnesia	2.04
Phosphoric acid	.207
Sulphur	.36
Total	99.167
Percentage of metallic iron	42.29

ALLEGHENY FORMATION

The Allegheny formation is composed of the rock strata in the interval, beginning with the Brookville coal and ending with the Upper Freeport. The materials are coals, clays, shales, sandstones, iron ores, and limestones. At present it is the most valuable formation in Jackson County. The twelve or more charcoal furnaces, during their period of iron making, and the later stone, coal, and coke furnaces for some years drew part or all of their supply of ore and limestone from this formation. It yet furnishes some limestone and ore for metallurgical purposes. The Allegheny clays are the basis of the important brick industry at Oak Hill, which has been very successfully carried on for many years. The coals are an important aid in maintaining the manufacturing industries of the county, as well as in affording a revenue from outside sources through shipment. The formation is found in Jefferson, Madison, eastern Franklin, Bloomfield, eastern Lick, Milton, eastern Coal, and eastern Washington townships. The members will be taken up in order, beginning with the lowest.

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[1] Geol. Surv. Ohio, Report for 1870, p. 150.

BROOKVILLE COAL

The Brookville is the lowest deposit of coal in the Allegheny formation. The bed in Jackson County is very unsteady, and, at present, is of importance only in the northern part of Milton Township. As it passes northward into Vinton County the member thickens, and is mined in a number of localities. South of Jackson County in Scioto and Lawrence, the Brookville coal is wanting or thin. It was occasionally observed along the Pine Creek Valley, and was last seen in the road tunnel north of Ironton where the bed measured 1 foot in thickness.

Stratigraphy and Area

The Brookville coal is wanting or poorly represented in Jefferson, Madison, Franklin, western Bloomfield, Lick, and Coal townships. A shaly blossom of coal was observed on the Black Flint horizon at a few places on the main ridges in the northern part of Washington Township. North of this in Richland Township, Vinton County, the bed thickens and becomes more steady. Along the road in the northeastern part of Section 32, Richland Township, the relations observed are as follows:

	Ft.	In.
Coal, *Brookville*	1	6
Clay and covered	1	6
Flint, *Black Flint*	1	--

East of Hamden Furnace, in Clinton Township, Vinton County, the Brookville coal is mined for a part of the local domestic supply. On the Tarr farm, in Section 32, the following measurements were obtained:

		Ft.	In.
Clay shale		--	5
Coal, good	*Brookville*	1	6
Clay		--	3
Coal, somewhat bony		1	1
Bone coal and shale		--	7
Clay and covered		1	6
Flint, *Black Flint*		1	10

The upper bench of coal here is reported to vary in thickness from 1 foot 6 inches to 2 feet, while the expansion of the interval from the Ferriferous limestone to the coal is reported to be from 18 to 30 feet.

Passing eastward from here the interval thins, until near Oreton, in Section 33, Vinton Township, the Brookville and Clarion coals are separated by only a few feet of shales. The following measurements were taken at the tunnel of the Hocking Valley Railway in the northeastern part of Section 33:

		Ft.	In.
Coal	*Clarion*	1	3
Clay with thin coal bands		--	8
Coal		1	2
Clay		--	1
Coal		1	3
Clay shale		1	3
Coal	*Brookville*	--	2
Clay shale		--	7
Coal		1	--

In northern Milton Township, Jackson County, the Brookville coal is quite persistent, but variable in thickness. On the land of the C. K. Davis Coal Company, Section 35, the following relations between the Lower Kittanning, Clarion, and Brookville coals were obtained:

		Ft.	In.
Coal blossom, *Lower Kittanning*		2	--
Clay and covered		6	--
Covered		5	--
Clay, light		4	--
Covered		10	--
Limestone, *Ferriferous*, flinty		4	--
Shale		7	--
Coal	*Clarion*	1	4
Clay with coal bands		--	8
Coal		1	2
Clay		--	1½
Coal		1	1
Clay		2	6
Sandstone		4	--
Coal blossom, *Brookville*		2	--

The Minglewood Coal Company is mining the Brookville coal for railroad shipment in Section 34. The structure of the bed, and its relation to the overlying Clarion coal, is shown in the following section made at the mines:

		Ft.	In.
Bone shale, black		1	1
Coal	*Clarion*	--	10
Coal, bony		--	3
Clay		--	6
Coal		1	2
Clay		--	1
Coal		--	8
Covered		4	9
Shale, gray		4	--
Shale with thin coal bands		1	--

		Ft.	In.
Coal	*Brookville*	2	--
Clay		--	1
Coal		--	8
Shale, gray		1	4
Ore band		--	2
Shale, gray		--	3
Coal		--	6

On the land of Hiram Walton, in Section 33, Milton Township, the blossom of the Brookville coal was again exposed, and the measurement is given below:

	Ft.	In.
Coal blossom, *Clarion*	3	--
Clay and covered	13	6
Coal blossom, *Brookville*	1	6

On the ridge east of the No. 12 mine of the Superior Colliery Company, both the Brookville and Clarion coals were exposed on the outcrop. The section measured there follows:

	Ft.	In.
Coal blossom, *Clarion*	4	--
Sandstone, argillaceous	4	--
Coal blossom, *Brookville*	2	--

In Section 32, on the ridge east of the mine of the Domestic Coal Company, both the Brookville and Clarion coals were again exposed for measurement, and the record obtained is given below:

	Ft.	In
Limestone, *Ferriferous*	5	--
Coal blossom, *Clarion*	4	--
Clay and shale	5	--
Coal blossom, *Brookville*	2	6

The Brookville coal is poorly represented south of Mulga Run and along the valley of Little Raccoon Creek, for in much of the area it is completely replaced by massive sandstones. Along the road in Section 11, on Rich Creek, the thin blossom was seen, and its position with regard to the Clarion coal above is shown in the section given below:

		Ft.	In.
Shale, black, fissile		1	8
Coal	*Clarion*	1	4
Clay with bone coal		--	8
Coal		1	2
Clay		--	1
Coal		1	1
Clay		3	--
Covered		22	--
Coal, *Brookville*		1	--

Since the horizon of the Brookville coal in most of Bloomfield Township is taken by massive sandstones but little evidence of this member was noted. At a few places, however, thin layers of impure coal, or of carbonaceous shale, which have a correlative position, are present.

Economic Value

The Brookville coal, although it cannot be considered an important addition to the mineral wealth of the county, is at present an asset of some value, and in the future the member may be of more worth for the bed in local areas in northern Milton Township has sufficient thickness for ease in mining. From surface indications the productive area is small, not exceeding 3 square miles, and it may be considerably less, as the bed is unsteady. The mining conditions are reasonably good, as the roof is a shale with moderate toughness, or a sandstone with massive development. In some places between the coal and sandstone there is a "draw slate" which is dangerous, or which causes additional expense if removed. The deposit is usually divided into two coal benches with a thin clay parting intervening. Often a third bench is present which is separated from those above by hard calcareous shales. The two upper benches together vary in thickness from 2 to 3 feet, but average about 2 feet 6 inches.

The Brookville coal belongs to the high volatile, free burning class but has good heating value. It is well liked for domestic, steaming, and other general purposes. The coal is bright and has a good appearance when prepared for the market, but it is somewhat tender thus causing some loss in shipment. The sulphur and ash of the Brookville compare favorably to that of the average market coal, and no troublesome clinker is reported to be produced in the burning of the fuel.

An analysis of the upper bench of the Brookville coal from the mine of the Minglewood Coal Company, in Section 34, Milton Township, shows the general character of the bed. The analytical work was done by Professor E. E. Somermeier, and the results recorded below:

Proximate analysis	
Moisture	9.31
Volatile matter	36.78
Fixed carbon	47.78
Ash	6.13
Total	100.00

Ultimate analysis	
Carbon	67.80
Hydrogen	5.70
Nitrogen	1.27
Oxygen	17.10
Sulphur	2.00
Ash	6.13
Total	100.00

Heating value:

Calories	6,976
B. t. u	12,233

Air drying loss, 4.90 per cent.

The carbon and hydrogen of the above ultimate analysis were obtained by calculation.

In Jackson County there is only one firm, the Minglewood Coal Company, mining the Brookville coal for railroad shipment. It is a pick mine with mule power for hauling. Small quantities of coal for domestic use are also mined by stripping. As the thicker beds become exhausted this deposit will be more largely used.

CLARION OR HECLA SANDSTONE

The Clarion member is the massive sandstone that lies below the Clarion coal, and, with few exceptions, is present wherever the latter is found. The division between this and the Homewood sandstone below, especially in the southern part of the county, is hard to determine, as the two appear to be one continuous bed without a break in deposition or a line of disconformity.

In some localities the stone in the upper part of the deposit is light-colored, quite free from iron oxides and mica, and it has clay for the bonding material. It is a medium grade ganister which was used in lining many of the charcoal furnaces during their periods of operation. At present it is used in lining Jefferson, the one remaining charcoal furnace in this state. A measurement of the strata in the quarry on the Jefferson Iron Company's land, Section 15, Jefferson Township, is as follows:

		Ft.	In.
Coal blossom, *Clarion*		2	--
Covered		3	--
Sandy shale		2	--
Sandstone	*Clarion*	1	5
Parting.			
Sandstone		2	6
Shale		--	1
Sandstone, light, massive, used for hearthstone		6	3
Parting.			
Sandstone, somewhat micaceous and ferruginous		10	--

The following section was taken at Madison Furnace, in Section 3, Madison Township:

	Ft.	In.
Ore, *Ferriferous*	--	6
Limestone, *Ferriferous*	7	--
Coal blossom, *Clarion*	3	--
Clay	4	--
Sandstone, massive, *Clarion*	30	--

The lower part of the furnace stack is cut out of the rock of this stratum.

The sandstone usually contains too much clay for its utilization as a glass sand, but, where properly crushed and prepared, it should yield sand well fitted for moulding purposes. The chemical quality of the Clarion sandstone is shown by the following analysis of a sample taken from the quarry of the Jefferson Iron Company west of Mount Horeb Church:[1]

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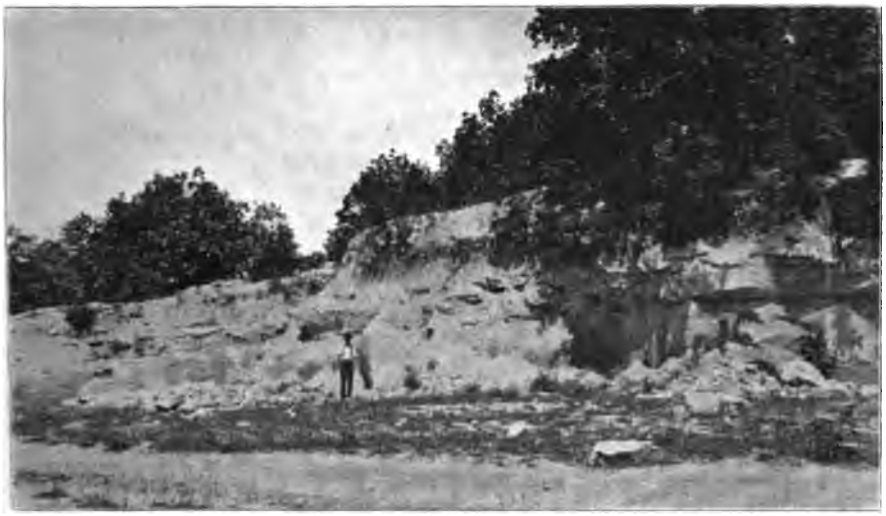
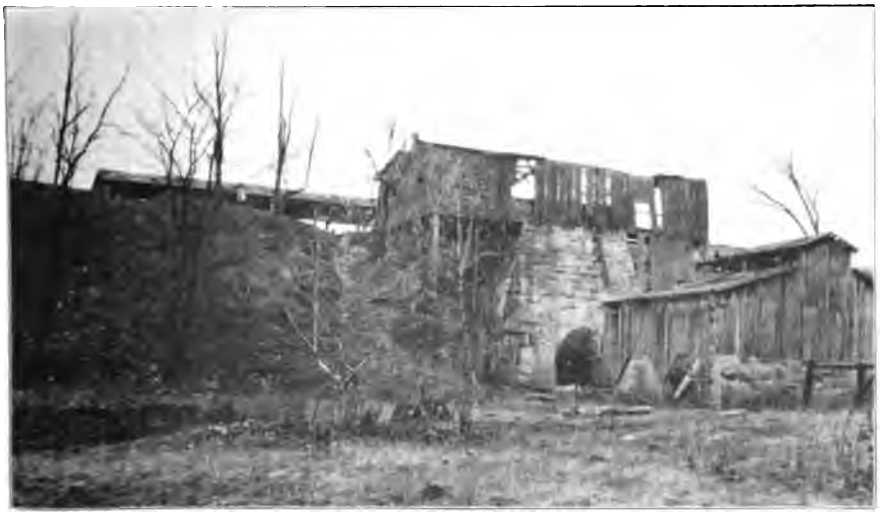
[1] H. B. Henderson and W. Stout, The Utilization of Ohio Clay-bonded Sandstones for Silica Brick Manufacture, Transactions of the American Ceramic Society, Vol. XXI.



A.—Clarion sandstone at the quarry of the Jefferson Iron Company west of Oak Hill. This stone has been used for many years in relining the stack, and it was largely used for this purpose by most of the charcoal furnaces in southern Ohio.



B.—Madison Furnace, northeast of Oak Hill, the lower part of which is cut from the massive Clarion sandstone in place.

Silica	88.60
Alumina	6.79
Ferric oxide	0.66
Lime	none.
Magnesia	0.11
Titanic oxide	trace.
Sodium oxide	0.16
Potassium oxide	1.70
Ignition loss	1.70
Total	99.72

CANARY ORE

This iron ore was not found well defined in Jackson County, but it has been worked in a few localities in Lawrence. Its position is a few feet below the Clarion coal or near the base of the clay.

CLARION OR NO. 4a COAL AND CLAY

The Clarion coal and clay in the eastern part of Jackson County are found with but few wants on the horizon at which they are due. The coal is one of the four most important beds in this county, and the clay has some value, but, on account of the thicker and better Kittanning clay above it has not been utilized. The total area of Clarion coal is large, and since the deposit has good thickness and has been mined but little the amount of fuel available will supply the local needs for many years. The quality of the Clarion coal is much below that of the Sharon, Quakertown, or Lower Kittanning, but as these coals are rapidly becoming exhausted it is only a question of a few years until the Clarion will become the main fuel reliance of the county. See map II facing page 194.

Extent and Stratigraphy

The position of the Clarion or No. 4a coal is either directly below the Ferriferous limestone, or it is separated from it by only a few feet of shales. The average interval from the Clarion coal to the Lower Kittanning is about 25 feet, but varies from 16 to 50 feet. The Clarion coal is found in parts of Hamilton, Franklin, and Lick townships, but is best represented in Madison, Bloomfield, and Milton townships.

Hamilton Township.—The Clarion coal just touches Hamilton Township. It is found near the summit of the main ridge in the southeastern corner of Section 36, but as the cover is shallow the coal is of little value.

Jefferson Township.—In Jefferson Township this member is represented in every section excepting the nine sections in the northwestern part. Along the main ridge and spurs from Section 31 to Mt. Horeb Church, Section 15, the bed is present, but, as the cover is shallow, the coal is more or less rotten. In Section 31, on land of Herman Geike, where the deposit is mined, the thickness reported for coal and partings is 3 feet 6 inches. The blossom of the Clarion coal exposed in the road in the southeastern part of Section 22 is as follows:

	Ft.	In.
Clay, *Oak Hill*	2	--
Coal blossom, *Lower Kittanning*	3	--
Clay and covered	8	--
Covered	9	--
Limestone, *Ferriferous*, seen	4	--
Coal blossom, *Clarion*	4	--

In Section 16, on the property of Andrew Leonard, the structure of the bed observed where the coal was being mined by stripping is as given below:

		Ft.	In.
Limestone, *Ferriferous*		5	--
Shaly material		1	--
Coal	*Clarion*	--	11
Shale parting		--	8
Coal		2	1

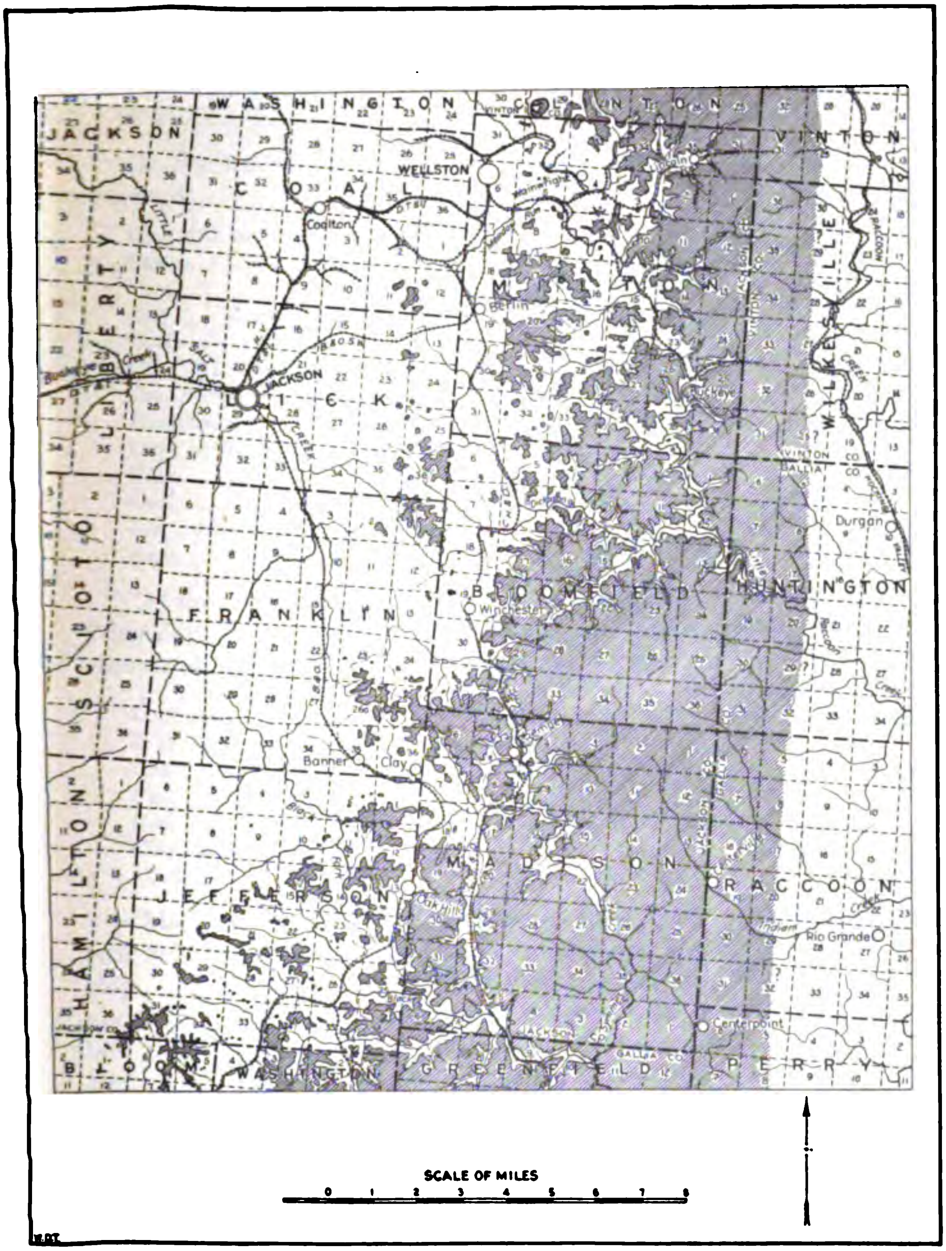
East of Black Fork in Jefferson Township the Clarion coal has more cover; hence it is of good quality. In Section 13, on the land of T. J. Davis, the structure of the bed in the mine of the Jackson Coal Company is as follows:

		Ft.	In.
Clay, plastic, ferruginous	*Oak Hill*	--	6
Clay, generally flint		3	6
Shale		7	--
Coal, *Lower Kittanning*, reported thickness		3	6
Clay		7	--
Covered		16	--
Ore, *Ferriferous*, reported thickness		--	5
Limestone, *Ferriferous*		7	--
Coal	*Clarion* or *No. 4a*	1	8
Shale		--	6
Coal		1	10
Sulphur band		--	1
Coal		--	10

In Section 25, on Jenkin W. Jones' land, the strata seen and reported are as given below:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Coal	*Clarion* or *No. 4a*	1	6
Clay		--	6
Coal		1	3
Clay, sulphur band		--	1
Coal		--	6

MAP II.



Clarion or No. 4a Coal in Jackson County.

On land of the Diamond Brick Company, in the same section, the following measurements were taken:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Coal	*Clarion*	1	3
Clay		--	8
Coal		2	--
Clay, sulphur band		--	2
Coal		--	8

In Section 36, on land of Robert Fox, the following relations were observed:

		Ft.	In.
Clay with ore nodules, *Oak Hill*		2	--
Shales		9	6
Coal	*Lower Kittanning* or *No. 5*	1	6
Clay		1	--
Coal		--	6
Clay, shales and covered		18	6
Ore, *Ferriferous*, reported		--	6
Limestone, *Ferriferous*		6	--
Coal, in places wanting	*Clarion* or *No. 4a*	--	10
Clay		--	5
Coal		1	5
Clay, sulphur band		--	1
Coal		--	5

At the mines of the Washington Coal Company, Section 34, Jefferson Township, the structure of the Clarion coal and its relations to other important members are noted in the record given below:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Shale		--	4
Coal	*Clarion*	1	--
Clay		--	5
Coal		1	6
Clay, sulphur band		--	1
Coal		--	6

Madison Township.—One of the most valuable parts of the Clarion coal field in Jackson County is in the western half of Madison Township. Along the western boundary of the township the coal is found about half way up the hills, but on account of the dip eastward the bed passes under cover near the middle part of the township. In Section 6, on land of Margaret Evans, the relations of the coal benches are as follows:

		Ft.	In.
Ore, *Ferriferous*		--	3
Limestone, *Ferriferous*		6	--
Coal, rotten, good in places and thickens to 1 foot	*Clarion*	--	4
Clay		--	5
Coal, good		1	8
Clay, sulphur band		--	1
Coal, good		--	10

The following measurements were taken on the property of W. D. Reese, Section 5:

		Ft.	In.
Ore, *Ferriferous*		--	3
Limestone, *Ferriferous*		7	--
Coal	*Clarion*	1	3
Clay		--	7
Coal		1	7
Shaly parting		--	2
Coal		1	--
Shale		--	7
Coal, bony		--	3

In the eastern part of this section the Clarion coal is also mined on the farm of John D. Jones, where the thickness of the coal and of the overlying limestone and ore are about the same as shown in the above record. The bed, however, where it passes from view in the western part of Section 4, is somewhat broken; hence good volume and steadiness east of this under cover is doubtful. This view is also warranted by the condition of the deposit along Black Fork Creek in northern Greenfield Township, Gallia County, where the coal is seldom present in force. The member has good thickness in sections 31 and 32, but its condition in sections 33, 34, 35, and 36 is not known, as the bed is below drainage level. One mile southeast of Oak Hill on land of Thomas, Williams, Section 30, the Clarion coal has the following structure:

		Ft.	In.
Limestone, *Ferriferous*		5	6
Coal	*Clarion*	1	4
Shale		--	5
Coal		1	5
Clay, sulphur band		--	1½
Coal		--	11

At the mines of the Oak Hill Fire Brick Company, in the same section, the rocks exposed were as given below:

		Ft.	In.
Clay, dark, ferruginous	*Oak Hill*	--	6
Clay, flint		2	--
Bone coal	*Lower Kittanning* or *No. 5*	--	4
Coal		1	10
Clay		--	5
Coal		--	8
Clay		9	4
Sandstone		5	10
Sandstone and shale		9	--
Ore, *Ferriferous*		--	4
Limestone, *Ferriferous*		6	--
Coal	*Clarion* or *No. 4a*	1	--
Shale		--	5
Coal		1	6
Clay, sulphur band		--	1
Coal		1	--

At the mines of the Etna Fire Brick Company the mine foreman reports the coal and partings to be about 4 feet in thickness, or about the same as noted in the above record. In Section 29 the Clarion coal is rather steady, but the Ferriferous limestone is often replaced by sandstones. The following section, taken on the land of J. D. Patterson, shows this condition:

		Ft.	In.
Sandstone, massive		10	--
Disconformity.			
Coal	*Clarion*	1	6
Clay		--	6
Coal		1	4
Clay		--	1
Coal		1	1
Clay		2	--

Adjacent outcrop conditions indicate that the Clarion coal is patchy in sections 28, 27, 26, and 25. In Section 19, on the property of Arizona E. and Myrta L. Evans, the following section was obtained:

		Ft.	In.
Ore, *Ferriferous*		--	10
Flint	*Ferriferous*	--	10
Limestone		5	--
Coal	*Clarion*, reported thickness	1	2
Shale		--	4
Coal		1	10

The Clarion coal is generally present where the member is exposed in sections 20, 21, and 22, but in local areas the overlying sandstone has replaced both limestone and coal. It is below drainage in sections 23 and 24. The areas of Clarion coal are small in Section 18, as the bed lies near the summits of the hills, but the coal is present where due. The member is also steady in Section 17, where the following composite record was obtained at the mines of the Pyro Clay Products Company:

		Ft.	In.
Ore, *Red Kidney*		--	2
Shale and shaly sandstone		11	--
Clay, part flint, *Oak Hill*		3	--
Shale		10	8
Coal	*Lower Kittanning*	--	2
Clay		--	2
Coal		2	2
Clay		--	2
Coal		--	5
Clay, dark, impure	*Lower Kittanning*	--	5
Clay, light, plastic		4	8
Clay, light, siliceous		4	7
Sandstone, clay-bond		2	--
Shale, sandy		14	--
Ore, *Ferriferous*		--	4

		Ft.	In.
Limestone, *Ferriferous*		8	--
Coal	*Clarion*	1	--
Clay		--	5
Coal		1	6
Clay		--	1
Coal		--	6
Clay		2	--

At the mines of the Elkhorn Coal Company, in the northwestern corner of Section 16, the Clarion coal has the following structure and relations:

		Ft.	In.
Ore, *Ferriferous*		1	--
Limestone, *Ferriferous*		9	--
Coal	*Clarion*	1	3
Clay		--	6
Coal		1	6
Clay		--	1
Coal		--	8
Clay		1	3

In this mine the upper bench of coal varies from 1 foot 3 inches to 1 foot 6 inches in thickness, but the other benches are quite regular. The Clarion coal has good volume where it is exposed near drainage level east of Moriah Church. As it passes from view in the western part of Section 15, its condition in section 14 and 13 is not known. In Section 7, on the land of F. H. Quick, the Ferriferous limestone in places is thin or wanting, and often the ore lies directly on the Clarion coal. A section taken follows:

		Ft.	In.
Coal	*Lower Kittanning*, reported thickness	2	5
Clay		--	3
Coal		1	--
Clay and covered		8	--
Sandstone, shaly		2	--
Clay, dark		3	--
Shale, ferruginous		1	4
Ore, *Ferriferous*		1	6
Coal, *Clarion*, reported thickness		2	6

Another section on the same property, but north of the above, shows the Clarion coal in normal development:

		Ft.	In.
Ore, *Ferriferous*		--	3
Limestone, *Ferriferous*		6	6
Coal	*Clarion*	1	5
Clay		--	6
Coal		1	5
Clay, sulphur band		--	½
Coal		--	10

The condition of the Clarion coal noted on the land of Enoch Morgan, in the northeastern part of Section 9, is as follows:

		Ft.	In.
Coal	*Clarion*	1	3
Clay		--	1
Coal		1	1

In restricted areas in this locality the massive sandstone replaces the limestone and coal completely, while at other places the coal and limestone may be present in their full thickness. In the above section the upper bench of coal is thus replaced by the sandstone. The coal is below cover in sections 10, 11, and 12. The strata exposed along the road south of Zoar Church, in Section 6, gave the following measurements:

		Ft.	In.
Shales		17	--
Coal	*Lower Kittanning* or *No. 5*	2	5
Clay		--	1
Coal		--	10
Clay		9	--
Shales and covered		18	--
Limestone, *Ferriferous*, weathered		3	--
Coal	*Clarion* or *No. 4a*	1	5
Clay		--	6
Coal		1	5
Clay, sulphur band		--	1
Coal		1	1
Clay		2	--

The Clarion coal was formerly worked on land of Evan Williams, in Section 6, Madison Township, and the Lower Kittanning is opened at present on the property of John W. Evans, Section 31, Bloomfield. A composite section is given below:

		Ft.	In.
Shale		4	--
Clay with thin coal bands		--	7
Coal	*Lower Kittanning*	2	5
Clay		--	½
Coal		1	--
Covered		20	--
Sandstone		3	--
Coal, *Clarion*, reported thickness		2	--

Mr. Evans reports that the sandstone above cuts out in places both the Ferriferous limestone and the upper bench of the Clarion coal. Near Madison Furnace, in Section 5, the structure of the Clarion coal is shown in the following record:

		Ft.	In.
Ore, *Ferriferous*		--	10
Limestone, *Ferriferous*		7	--
Coal	*Clarion*	1	3
Clay		--	5
Coal		1	7
Clay, sulphur band		--	1
Coal		1	2

The Clarion coal is quite steady and has good volume in Section 4, but east of this in Section 3, where it passes below drainage, the bed is patchy and often thin.

Franklin Township.—In Franklin Township the Clarion coal and clay are found near the summits of the ridges and spurs in sections 23, 24, 25, 26, 35, and 36, in the southeastern part, and a small area in sections 1 and 2, in the northeastern part. The following structure of the coal was observed in a mine on the land of Albert Evans, in the northeastern part of Section 36:

		Ft.	In.
Limestone, *Ferriferous*, flinty, weathered		3	--
Soft clay shale on outcrop		2	--
Coal, shaly	*Clarion*	--	2
Coal		1	3
Clay shale		--	4½
Coal		1	5
Clay, sulphur band		1	--
Coal		--	10
Clay		1	--

Near the Jackson-Oak Hill pike, in Section 25, on the land of M. L. Sternberger, the coal and clay benches measured as follows:

		Ft.	In.
Ore, *Ferriferous*		--	4
Limestone, *Ferriferous*		6	--
Shale		--	4
Coal, soft, weathered	*Clarion*	--	8
Clay shale		--	8
Coal		1	4½
Clay, sulphur band		--	1½
Coal		--	10

East of Camba, in Section 25, on land of James A. Henson, the Clarion bed has been mined, and the coal is reported as follows:

		Ft.	In.
Ore, *Ferriferous*		--	5
Limestone, *Ferriferous*		7	--
Coal	*Clarion*	1	3
Clay		--	6
Coal		1	3
Shale and sulphur band		--	2
Coal		--	10

Bloomfield Township.—The Clarion coal and clay horizon in western Bloomfield Township is found well towards the summits of the hills, but the dip eastward throws the members under cover in the valley of Little Raccoon Creek. In Section 31 the Clarion coal is somewhat unsteady, for in places the massive sandstone above replaces the Ferriferous limestone and the upper bench of coal. The coal is practically wanting in sections 30 and 19, for the bed has been removed through the erosive agencies of the old preglacial river. At old Limestone Furnace, in Section 32, the Clarion coal was formerly mined for railroad shipment. The bed here has excellent thickness, and in only a small part of the area is exhausted. The record obtained and given below shows the following general relations:

		Ft.	In.
Coal	*Lower Kittanning*	1	10
Clay		--	2
Coal		--	6
Sandstone, shaly		3	--
Shales, sandy		15	--
Ore, *Ferriferous*, not seen.			
Limestone, *Ferriferous*		7	--
Coal	*Clarion*	1	3
Clay		--	4
Coal		1	9
Clay, sulphur band		--	2
Coal		--	10

The Clarion coal is rather steady where it disappears from view in the western parts of sections 28 and 33. It is below cover in sections 34, 35, 36, 25, 26, and 27; hence its condition in this area is not definitely known, but from outcrop conditions to the north of this the bed is regarded patchy. Both the Clarion coal and Ferriferous limestone are generally found in normal development in Section 20, where the following record was obtained, on the land of the Southern Ohio Portland Cement Company:

		Ft.	In.
Ore, *Ferriferous*		1	--
Limestone, *Ferriferous*		7	--
Coal	*Clarion*	1	--
Clay		--	5
Coal		1	8
Clay		--	1
Coal		1	4

The Clarion coal is patchy in sections 21, 22, 23, and 24, as it is locally replaced by massive sandstones. In Section 17 the member is quite regular and has normal volume, as shown by the following record obtained on the land of George Scurlock:

		Ft.	In.
Limestone, *Ferriferous*		8	--
Shale		--	2
Coal	*Clarion*	1	6
Clay		--	5
Coal		1	4
Clay		--	1
Coal		1	--
Clay		1	--

This patchy condition is also found for the Clarion coal in Section

16, where the following measurements were taken, on the farm of John Ginan:

		Ft.	In.
Limestone, *Ferriferous*		6	--
Coal	*Clarion*	1	8
Clay		--	8
Coal		1	4
Clay		--	1
Coal		--	8
Clay and clay-bond sandstone		5	--

Both coal and limestone have excellent volume in Section 15, where the record given below was obtained, on the land of Taylor Munyon, and was duplicated also on that of William Arthur:

		Ft.	In.
Ore, *Ferriferous*		--	4
Limestone, *Ferriferous*		7	--
Shale		--	4
Coal	*Clarion*	1	10
Clay		--	7
Coal		1	4
Clay		--	1
Coal		1	--
Clay		2	--

West of the above in sections 14 and 13 the coal is somewhat unsteady. Only small isolated patches of coal are found on the summits of the high knobs in sections 18, 7, and 6, while in sections 5 and 8 the coal areas are somewhat larger, but the cover is generally shallow; hence the coal is rotten. In Section 9 the Clarion coal was formerly worked for railroad shipment. The bed at the mine of George Eagle has the following structure:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Shale		--	1
Coal	*Clarion*	1	10
Clay		--	8
Coal		1	4
Clay		--	2
Coal		--	11
Clay		2	--

In Section 4 the area is large, but the bed is somewhat unsteady, as in places it is partially replaced by the heavy sandstone above. In Section 3 the Clarion coal has good volume and is quite regular, for the Ferriferous limestone above is generally present. A section taken on land of Anna Dillinger shows the structure and thickness of the bed as follows:

	Ft.	In.
Ore, *Ferriferous*	--	5
Limestone, *Ferriferous*	7	--
Shale	--	2

		Ft.	In.
Coal	*Clarion*	1	9
Clay		--	5
Coal		1	3
Clay, sulphur band		--	1
Coal		--	10
Clay sandy		1	--

In this section, on land of the Superior Colliery Company, the the same general relations were found. In sections 2 and 11 the bed normally has good volume, but it is occasionally partially replaced by the heavy overlying sandstone, and this condition is also found in sections 1 and 12. On land of James Davis, in Section 1, the record given below shows the relation of the massive sandstone, which here has replaced the Ferriferous limestone, to the Clarion coal below:

		Ft.	In.
Sandstone and covered		24	--
Sandstone, with finger coal		8	--
Disconformity.			
Coal	*Clarion*	1	4
Clay with thin coal bands		--	8
Coal		1	2
Clay, sulphur band		--	1
Coal		--	10
Coal, bony		--	4

The massive sandstone above often partially, and in some localities completely, replaces the Clarion coal. Another measurement obtained on land of the McKeldon Mining Company shows much the same relation.

Lick Township.—The Clarion coal is present only in the eastern part of Lick Township. Small isolated patches of coal are found on the high ridges and hills in sections 36, 35, 25, 26, 24, 23, 13, and 14, but the cover is shallow, and the coal of little value. In Section 36, on the land of James and William McDaniel, coal is mined for local use. The structure of the Clarion bed here is shown in the section given below:

		Ft.	In.
Flinty lime and ore	*Ferriferous*	1	8
Limestone, partially decomposed		2	--
Shale, dark		--	10
Coal	*Clarion*	1	2
Clay with coal bands		--	8
Coal		1	6
Clay		--	1
Coal		1	--

Coal Township.—In Coal Township the Clarion coal is present on the high hills in sections 11 and 12, but the bed is partially replaced by the sandstone above. The deposits are of no value. The coal was not found in Washington Township.

Milton Township.—Milton Township is well supplied with Clarion coal. The member is present near the summits of the ridges in the western part, but the dip eastward carries it below drainage near the eastern boundary. The bed is quite persistent, although in some localities the massive sandstone above has not only replaced the limestone, but also a part or all of the coal. The coal is wanting in Section 31, and only small areas are present in sections 30 and 32. It was formerly mined for railroad shipment in Section 29, and is mined at present for local use near Latrobe Furnace. A section obtained on the land of the McKeldon Mining Company, and given below, shows the general character of the bed:

		Ft.	In.
Shale, dark, fissile		1	1
Coal	*Clarion*	1	9
Clay with thin coal bands		--	8
Coal		1	6
Clay, sulphur band		--	1
Coal		--	11

In sections 27, 28, 33, and 34 the Clarion coal is somewhat unsteady, for in local areas the bed is partially or completely replaced by the sandstone above. This condition was also found in sections 25, 26 35, and 36. Where the limestone is present the coal is normal, but where this is replaced by the sandstone the character of the coal bed below is uncertain. The following record was measured in Section 26 along the road that leads to the ridge west of Little Raccoon Creek and near Buckeye Furnace:

		Ft.	In.
Coal blossom, *Lower Kittanning* or *No. 5*		1	--
Clay, light		5	--
Sandstone, shaly		24	--
Ore, *Ferriferous*		--	4
Limestone, *Ferriferous*		5	6
Coal	*Clarion* or *No. 4a*	1	8
Clay with thin coal bands		--	8
Coal		1	4
Clay, sulphur band		--	2
Coal		1	--
Coal, bony		--	2

On Greasy Run, in Section 36, on the land of the Superior Colliery Company, the Ferriferous limestone is generally well developed, and the Clarion coal below has good volume. A section taken here is as given below:

		Ft.	In.
Limestone, *Ferriferous*, good		8	--
Coal	*Clarion*	1	7
Clay with coal bands		--	8
Coal		1	4
Clay, sulphur band		--	1
Coal		1	3

Along Buffer Run, in Section 24, the Clarion coal is quite steady, for the limestone above is generally present. In Section 13, at mine No. 10 of the Superior Colliery Company, where the Clarion coal goes below drainage, the structure of the bed is shown in the following measurements:

		Ft.	In.
Limestone, upper part flinty, *Ferriferous*		5	--
Shale, gray		--	5
Shale, dark, fissile		2	2
Coal	*Clarion*	1	4
Clay		--	8
Coal		1	4
Clay, sulphur band		--	1
Coal		1	1

In Section 14 the Clarion coal is unsteady, but where present it usually has good thickness. This is also true of the member in Section 23. The following section, which was measured on the land of the Superior Colliery Company, shows the general character of the bed when normal:

		Ft.	In.
Sandstone		20	--
Coal	*Clarion*	1	3
Clay with thin coal bands		--	8
Coal		1	5
Clay		--	1
Coal		1	3
Clay		1	--

Near by the Clarion coal is completely replaced by the sandstone above. The unsteady character of the Clarion bed is shown by the following record, taken on land of J. W. O'Neill, in the same section:

		Ft.	In.
Sandstone, massive		53	--
Sandstone, with irregular lenses of coal, *Clarion*		2	--
Sandstone		5	--
Covered		25	--
Shale, dark, tough		1	--
Coal, cannel	*Tionesta*	--	1½
Coal, bituminous		--	2½
Clay shale, dark		1	3
Coal, cannel, bony		--	8
Coal, cannel, good		1	10
Coal, cannel, bony		--	4

In Section 15, on the land of James E. Goddard, the following measurement was made:

		Ft.	In.
Shale, black, fissile		2	6
Coal	*Clarion*	1	5
Clay with thin coal bands		--	8
Coal		1	4
Clay		--	2
Coal		1	4
Clay, siliceous		1	2
Coal, bony		--	4½
Clay		1	--

On the ridges in Section 22 the Ferriferous limestone is usually present, and the coal below has good thickness. In Section 21 the coal areas are small and the cover shallow. Along the main ridge in Section 16 the Clarion coal is mined in several places for local domestic use. On the J. H. Scurlock property the structure of the bed noted is given in the section below:

		Ft.	In.
Coal	*Clarion*	1	3
Clay with coal bands		--	9
Coal		1	3
Clay, sulphur band		--	½
Coal		--	11

In Section 17 the Clarion bed furnishes a part of the local fuel supply and is well developed. A section taken on land of V. A. Pettinger is given below:

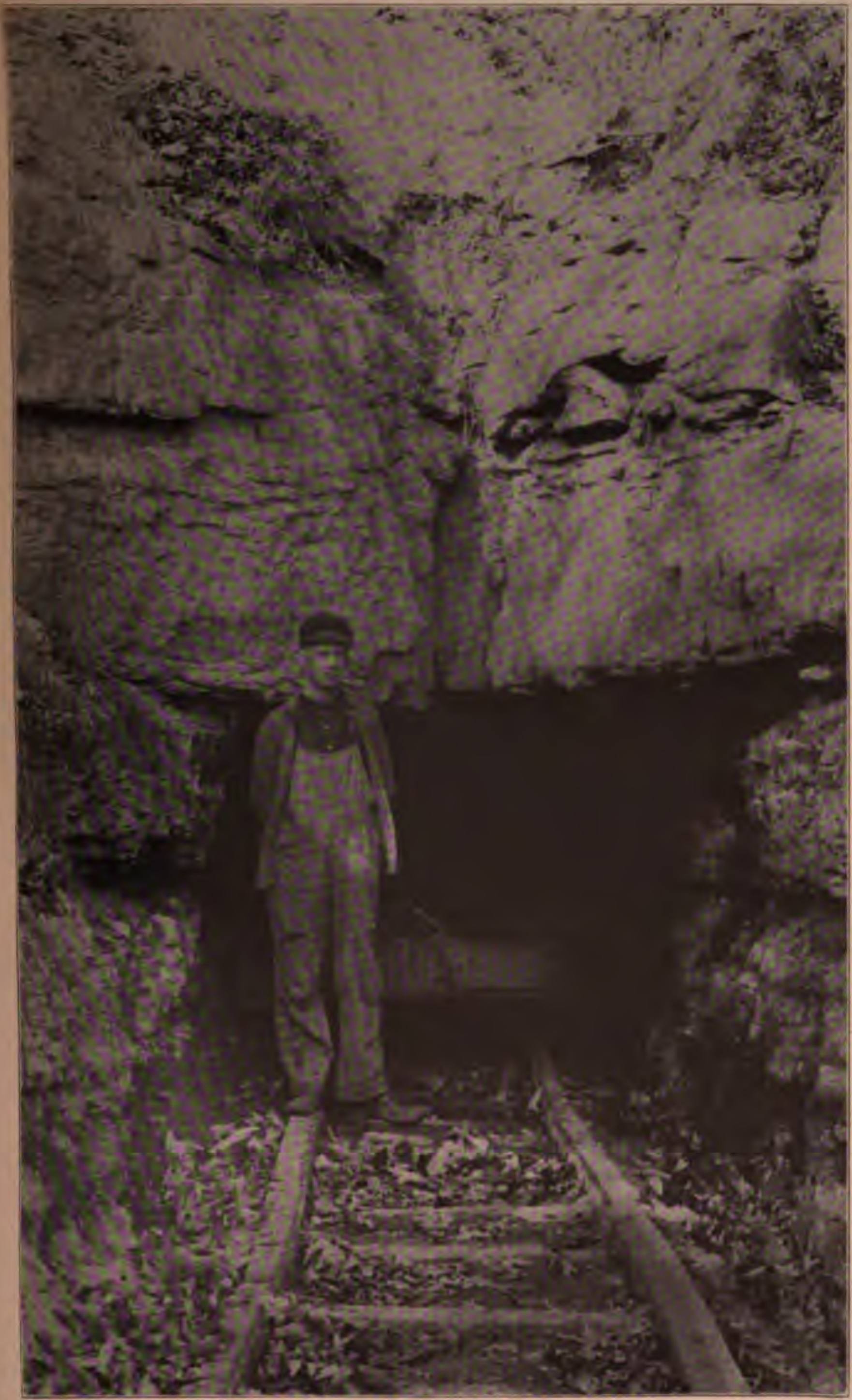
		Ft.	In.
Shale, black, fissile		1	6
Coal	*Clarion*	1	1
Clay with coal bands		--	10
Coal		1	4
Clay, sulphur band		--	1
Coal		1	2

The Clarion coal has good volume also in Section 20, but no measurements were obtained. In Section 19 the coal area is small, on account of the erosion of the preglacial river. In Section 18, north of Berlin, small quantities of fuel are mined for local use, and a section obtained shows the following structure of the bed:

		Ft.	In.
Limestone, *Ferriferous*, flinty		3	--
Shale, black, fissile		2	--
Coal	*Clarion*	1	2
Coal, bony		--	4
Clay		--	6
Coal		1	5
Clay, sulphur band		--	1
Coal		1	--

In Section 6 the Clarion coal is wanting, and in Section 7 it is found in the southeastern corner. In Section 5, on land of James L. Johnson, the coal is mined for local use, and the measurements obtained follow:

		Ft.	In.
Shale, black, fissile		2	--
Shale, soft, black		--	4
Coal	*Clarion*	1	1
Clay with thin coal bands		--	10
Coal		1	5
Clay, sulphur band		--	1
Coal		1	--



Clarion coal with the overlying Ferriferous limestone in Bloomfield Township, Jackson County. The bottom of the coal is about 6 inches below the track level and the top is in contact with the limestone.

On land of George Woodrow, in Section 8, the coal is mined for local use by stripping, and the section obtained there is given below:

		Ft.	In.
Shale, black, fissile		3	--
Coal	*Clarion*, reported thickness	1	2
Clay with coal bands		--	8
Coal		1	--
Clay		--	1
Coal		1	--

In sections 4 and 9 the coal areas are small, but the bed is worked for local use. In the latter section, on the Jacob L. Tucker property, the rocks exposed at a mine are as given below:

		Ft.	In.
Limestone, *Ferriferous*, upper one foot flinty		5	--
Shale, gray		--	9
Shale, black, fissile		1	8
Coal	*Clarion*	1	5
Clay with thin coal bands		--	8
Coal		1	4
Clay, sulphur band		--	1
Coal		1	3

The Clarion coal is again unsteady in Section 10, but in some localities has about its normal thickness. On the hill just east of the mouth of Mulga Run the bed near the outcrop measured as follows:

		Ft.	In.
Shale, black, fissile		1	8
Coal	*Clarion*	1	5
Clay and bone coal		--	7
Coal		--	8
Clay		--	2
Coal		1	--

North of this the Clarion was seen represented only by finger coal in the massive sandstones. The member is again normally developed on the land of Adam Phillips, in Section 3, where the following measurements were taken:

		Ft.	In.
Ore, *Ferriferous*		--	5
Limestone, *Ferriferous*, good		6	--
Shale, gray		--	9
Shale, black, fissile		1	9
Coal	*Clarion*	1	5
Clay with coal bands		--	6
Coal		1	2
Clay, sulphur band		--	1
Coal		1	3
Clay shale, dark		--	7
Coal, bony		--	9

In the northern part of this section the Clarion coal was formerly mined for railroad shipment. On land of Isaac Palmer the bed is mined for local use, and the structure found is as follows:

		Ft.	In.
Shale, black, fissile		1	3
Coal	*Clarion*	1	5
Clay with coal bands		--	8
Coal		1	4
Clay, sulphur band		--	1
Coal		1	2
Clay		1	1
Coal		--	10
Clay		2	6

A composite section taken along the road from Rich Run to Union School, on the hill north, shows the general relations of the Allegheny coals, and the measurements made are given below:

		Ft.	In.
Coal blossom, *Upper Freeport* or *No. 7*		5	--
Clay		1	--
Sandstone, coarse-grained		20	--
Covered		19	--
Clay shale		7	--
Sandstone, shaly		9	--
Sandstone, nodular, lime-bond		2	--
Sandstone, shaly		13	--
Clay shale, soft		3	--
Coal blossom		--	3
Clay shale		--	9
Shale and covered		15	--
Coal blossom, *Middle Kittanning* or *No. 6*		1	4
Clay shale		1	8
Shale		14	--
Sandstone, shaly		10	--
Covered		5	--
Clay, plastic	*Oak Hill*	2	--
Clay, flint		2	--
Shale, part sandy		29	--
Coal blossom, *Lower Kittanning* or *No. 5*		3	--
Clay		5	--
Sandstone, light, clay-bond		10	--
Sandstone, massive		9	--
Shale, black, fissile		1	8
Coal	*Clarion* or *No. 4a*	1	4
Clay with coal bands		--	8
Coal		1	2
Clay, sulphur band		--	1
Coal		1	1
Clay		3	--
Covered		22	--

East of Mulga Run, in Section 2, on the land of the Superior Colliery Company, where opened for local use, the bed shows the following structure:

		Ft.	In.
Shale, dark, fissile		1	2
Coal	*Clarion*	1	3
Clay with coal bands		--	7
Coal		1	4
Clay, sulphur band		--	1
Coal		1	2

In Section 12, on the land of the Wellston Coal and Brick Company, the Clarion coal was exposed for measurement, while the outcrops of the Lower and Middle Kittanning coals were also noted. The section obtained near where a shaft was sunk for Quakertown coal is given below:

		Ft.	In.
Coal blossom, *Middle Kittanning* or *No. 6*		1	--
Clay		1	--
Shale		21	--
Clay shale		2	--
Clay with large ore nodules		2	--
Clay flint, *Oak Hill*		2	--
Clay shale		1	--
Shale		1	--
Shale with irregular bands of kidney ore		3	--
Shale, gray		19	--
Clay shale		1	--
Coal, bony	*Lower Kittanning* or *No. 5*	--	6
Coal, good		1	8
Clay		--	2
Coal, good		--	4
Clay		1	--
Sandstone, shaly		7	--
Covered		15	6
Sandstone		3	--
Disconformity.			
Shale, fissile, black		1	3
Coal	*Clarion* or *No. 4a*	1	3
Clay with coal bands		--	6
Coal		1	2
Clay, sulphur band		--	1
Coal		1	2
Covered		--	7
Top of shaft.			

The Clarion coal is below drainage in Section 1, but it has been worked for railroad shipment in Section 36. On land of the Geneva Coal and Mining Company the following measurements were obtained:

		Ft.	In.
Sandstone, massive		32	--
Coal	*Clarion*	1	1
Clay with coal bands		--	5
Coal		1	3
Clay, sulphur band		--	1
Coal		1	3

The Geneva Coal and Mining Company also mined the Clarion coal for railroad shipment in Section 35. The structure of the bed where measured is as given below:

		Ft.	In.
Coal	*Clarion*	--	9
Coal, bony		--	3
Clay		--	5
Coal		1	3
Clay, sulphur band		--	2
Coal		1	3

Another measurement taken near by is as follows:

		Ft.	In.
Ore, *Ferriferous*, irregular		--	4
Limestone, flinty	*Ferriferous*	3	--
Limestone, good		3	--
Coal	*Clarion*	1	--
Coal, bony		--	4
Clay		--	6
Coal		1	3
Clay		--	2
Coal		1	3

The above sections illustrate the great irregularity of the shales between the Clarion coal and Ferriferous limestone. The limestone may lie directly on the coal or it may be separated from it by 8 or more feet of intervening shales. The changes here are very sudden and the coal is subject to dips and rolls, which are troublesome in mining. In the same section on the land of C. K. Davis the Clarion coal was also exposed for measurement, and the record obtained follows:

		Ft.	In.
Limestone, *Ferriferous*, flinty		4	--
Shale		7	--
Coal	*Clarion*	1	4
Clay with coal bands		--	8
Coal		1	2
Clay		--	1½
Coal		1	1
Clay		2	6

At the mines of The Minglewood Coal Company, in Section 34, the structure of the Clarion coal near the outcrop is as given below:

		Ft.	In
Coal	*Clarion*	--	10
Coal, bony		--	3
Clay		--	6
Coal		1	2
Clay, sulphur band		--	1
Coal		--	8

The Clarion coal has normal thickness in Section 33, and the bed is persistent, but in Section 32 the heavy sandstone above has replaced the upper bench of coal.

Under heavy cover in eastern Milton Township it seems quite probable that the Clarion coal has its normal development and is generally steady, for it is well represented along Raccoon Creek in Vinton County. The general structure of the bed in this region is illustrated by the following section taken on the land of Frank Stanton, in Section 28, Wilkesville Township, Vinton County:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Shale, gray		--	2
Shale, dark, fissile		1	--
Coal	*Clarion*	1	6
Clay		--	7
Coal		1	2
Clay, sulphur band		--	1
Coal		1	5

Structure of Bed

Normally the Clarion coal is made up of three main coal benches separated by partings. The average structure of the bed in Jackson County is as follows:

	Ft.	In.
Coal, upper bench	1	3
Parting	--	7
Coal, middle bench	1	4
Parting	--	1
Coal, lower bench	1	--

Occasionally one or two thin coal benches are found below the 1 foot layer, but these are usually bony and of no value. In a few localities the upper bench is wanting as it is replaced by a heavy sandstone, while at other places it was seen either rotten or replaced by a mixture of shales and coal. The maximum thickness found for this bench was 1 foot 9 inches. The clay or clay shale parting below this bench varies from 4 to 10 inches, but averages about 7 inches in thickness. It is usually rather soft in character and is used as a means of attack in mining the coal. The middle bench which averages 1 foot 4 inches in thickness varies from 1 foot to 1 foot 10 inches. It is separated from the lower bench by a thin parting varying from one-half to 2 inches in thickness. This parting is made up of clay or shale with layers or nodules of pyrite or marcasite which often constitute the bulk of the stratum. The lower bench varies from 6 to 16 inches in thickness, but the normal measurement is close to 12 inches.

Area of Field and Yield

The total area of the Clarion coal field in Jackson County approximates closely 75 square miles, which exceeds the combined areas of the known Sharon and Quakertown fields, for the area of the former is about 25 square miles while that of the latter is nearly 40. Although subject to some wants and to some thinning by the sandstone above the bed is more uniform in thickness than either the Sharon or Quakertown and far more persistent than the former. The Clarion coal is usually solid close to the outcrop, for the limestone and hard fissile shales above afford some protection from the agencies of weathering. This coal has been worked in a large way in only a few localities, and where mined for local use, the bed has been attacked only along the outcrop; consequently the main coal body is yet untouched, and it forms the valuable reserve fuel supply of the county. When the known areas, in which the coal is wanting, the parts exhausted by mining, and the crop borders are subtracted, the area of the field in which the coal is expected will reach at least 40 square miles. The average thickness of the coal alone in the bed in Jackson County is 3 feet 7 inches, and the specific gravity is 1.34. Computing from these, the total yield per acre is about 6,536 tons of 2,000 pounds each. If 60 per cent only is available in mining the yield is 3,922 tons per acre or 2,510,080 tons per square mile. All things considered the Clarion is the most valuable coal bed in Jackson County and assures an ample supply of fuel for many years after the Quakertown and Sharon coals have been exhausted.

Development of Field

Small tracts of Clarion coal were formerly worked near Kitchen, Section 32, Madison Township, and at Limestone, Section 32, Bloomfield Township, for railroad shipment. These mines were abandoned and have fallen in. The Jackson Coal Company operates a small mine just west of Oak Hill for coaling engines on the Portsmouth branch of the Baltimore and Ohio Southwestern railroad. On an average, 16 men are employed and the daily output is about 50 tons. The Washington Coal Company near Monroe mines the Clarion coal for railroad shipment and also shoots down from 4 to 5 feet of the limestone above, which is crushed and sold for furnace flux, road ballast, and other purposes.

Mines are operated at present by George Eagle, in Section 9, Bloomfield Township, for railroad shipment. Although worked for several years the territory is far from being exhausted. On Rich Run, in sections 12 and 13, Milton Township, the Superior Colliery Company has a railroad mine, which is now in operation. Near Lincoln Furnace, in sections 2, 35, and 36, the Clarion coal was formerly worked in several mines, but these are abandoned or idle at present (1916). It was also worked for railroad shipment in Section 3. More or less coal for local domestic supplies is drawn from this member along its entire outcrop in Jackson County, but as a whole the field has scarcely been touched.

Mining Conditions

The Ferriferous limestone, which is present, with few exceptions, in the southern half of the Clarion coal field, forms the roof, and either a siliceous clay or a sandstone forms the floor of the bed. Under shallow cover, or where the weathering has been severe, the limestone may be separated into blocks, with mud seams between, varying from an inch to 2 feet or more in width, which condition makes the mining somewhat dangerous, but this seldom extends far under cover. In a few localities, and there along the outcrop especially, the upper coal bench is partially or completely decayed, and the space filled with a soft muddy material, which is made up of the rotten coal with weathered shale that has been carried by the water from above the limestone through the joint planes. Under this condition the mining of the coal is both costly and dangerous. Where neither coal nor limestone have been modified by weathering, the mining conditions are very safe and good.

In the northern part of the field a hard fissile shale is found directly above the coal. This varies in thickness from a few inches to 3 feet, but usually it measures from 1 to 2 feet. Above this in local areas from 1 to 6 feet of gray shales are present. The next rocks encountered above the shales are either Ferriferous limestone and ore, or the massive sandstones which often replace these members. Either the shale, limestone, or sandstone forms an excellent roof, so that the mining conditions are quite safe; hence the yield of the bed should be high, at least 80 per cent. The floor is either a siliceous clay or a sandstone, both of which are well able to bear the weight of the overburden.

The two partings in the deposit are objectionable. The upper parting of clay or shale, about 7 inches in thickness, will produce about 800 pounds of material per square yard, which must be removed from the mine or thrown back in the rooms. Also, in mining, more or less of this material becomes mixed with the coal, which thus impairs its value. The lower parting, seldom over 2 inches in thickness, is especially objectionable. It is made up of clay or shale, with nodules and bands of pyrite or marcasite. If care is not used in separating this material the sulphur content of the coal, which normally is high, is excessive, often being more than doubled in amount.

The sandy clay or argillaceous sandstone floor of the bed is sufficiently solid to hold the posts and coal blocks left for the roof supports. The character of the material makes the digging of drains, when this is required, somewhat costly. The coal is quite uniform in thickness, and it shows but few rolls or dips, so that when the mine is driven with the general rise of the strata little difficulty is experienced in draining.

The average thickness of coal and partings is more than 4 feet, which is ample for ease of working in the rooms. In the entry ways, if mule power is used in haulage, part of the limestone must be shot down to gain sufficient height, but this does not impair the safety of the roof, and the value of the limestone usually pays for its removal. All points considered the mining conditions of the Clarion coal are on a par with those of other important coals of the state.

Utilization and Value

In quality the Clarion or No. 4a coal is rated low in the scale of Ohio coals. The main objections are the high contents of sulphur and ash, which in this coal produce a hard clinker and a severe corrosion of the metal parts exposed in the grates. The heating value of the Clarion is also below the normal for Ohio coals. The quality of the coal is shown by the following analyses:[1]

Hall's Mine, Kitchen Station, Madison Township, Jackson County. Sample cut well under the hill. Limestone roof. Sampled by Professor Edward Orton, Jr., in August, 1900.

Chemical Analysis and Calorific Value

Ultimate		*Proximate*	
Carbon	62.57	Moisture	4.90
Hydrogen	4.89	Volatile matter	35.75
Oxygen	11.47	Fixed carbon	45.65
Nitrogen	1.23	Ash	13.70
Sulphur	6.14		
Ash	13.70		

Calorific value { 6,460 calories.
11,628 B. t. u.

Old Limestone Furnace, Section 32, Bloomfield Township, Jackson County. Sample cut about 300 feet from entry. Limestone roof. Sampled by Professor Edward Orton, Jr., in August, 1900.

Chemical Analysis and Calorific Value.

Ultimate		*Proximate*.	
Carbon	62.05	Moisture	5.31
Hydrogen	4.98	Volatile matter	37.33
Oxygen	12.12	Fixed carbon	43.82
Nitrogen	1.23	Ash	13.54
Sulphur	6.08		
Ash	13.54		

Calorific value { 6,394 calories.
11,509 B. t. u.

Pettinger Mine, Wellston, Jackson County. The coal has a shale roof. Sampled by Professor Edward Orton, Jr., August, 1900.

Chemical Analysis and Calorific Value.

Ultimate		*Proximate*	
Carbon	66.52	Moisture	5.33
Hydrogen	5.50	Volatile matter	41.01
Oxygen	14.58	Fixed carbon	45.26
Nitrogen	1.28	Ash	8.40
Sulphur	3.72		
Ash	8.40		

Calorific value { 6,825 calories.
12,285 B. t. u.

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[1] Geol. Surv. Ohio, Fourth Ser., Bull. 9, pp. 174-179.

Country Bank of Superior Coal Company, Section 36 South, Milton Township, Jackson County. Sample cut from 75 to 80 feet from entry. The mine had been worked recently and the surface of the coal appeared fresh. Sampled by Professor Edward Orton, Jr., in August, 1900.

Chemical Analysis and Calorific Value

Ultimate		*Proximate*	
Carbon	67.51	Moisture	4.71
Hydrogen	5.44	Volatile matter	40.51
Oxygen	13.45	Fixed carbon	46.17
Nitrogen	1.26	Ash	8.61
Sulphur	3.73		
Ash	8.61		

Calorific value 6,911 calories.
12,440 B. t. u.

Country Bank of Superior Coal Company, Section 13, Milton Township, Jackson County. Sample cut about 50 to 60 feet in the hill in comparatively new workings. Shale roof. Sampled by Professor Edward Orton, Jr., in August, 1900.

Chemical Analysis and Calorific Value

Ultimate		*Proximate*	
Carbon	66.14	Moisture	4.98
Hydrogen	5.39	Volatile matter	39.71
Oxygen	13.31	Fixed carbon	45.51
Nitrogen	1.28	Ash	9.80
Sulphur	4.08		
Ash	9.80		

Calorific value 6,801 calories.
12,242 B. t. u.

Iron Valley Mine, Section 35, Milton Township, Jackson County. Sample cut from entry about 300 feet in. Mine had been idle two years but surface of coal appeared fresh. Sampled in 1900 by Professor Edward Orton, Jr.

Chemical Analysis and Calorific Value

Ultimate		*Proximate*	
Carbon	67.30	Moisture	5.61
Hydrogen	5.47	Volatile matter	38.92
Oxygen	14.16	Fixed carbon	47.38
Nitrogen	1.28	Ash	8.09
Sulphur	3.70		
Ash	8.09		

Calorific value 6,863 calories.
12,353 B. t. u.

The average heating value of the above six samples is 6,709 calories, or 12,076 B. t. u., while the sulphur amounts to 4.58 per cent and the ash to 10.39 per cent. The Clarion is a short-flamed coal, yet the volatile matter is high. Although classed as a free-burning coal, it burns readily only for the short period required to expel the volatile matter, after which the remainder is consumed slowly, unless the draft is strong.

For steaming purposes the most serious objections to the Clarion coal are the rapid removal of the metal parts exposed to the fuel bed, due to the formation of metallic sulphides, and the clinkering of the ash, which thus requires constant attention in firing. The sulphur attacking the exposed parts soon produces a thick scale on the metal, which also becomes brittle through changes in composition. To prevent this the grates should be kept clean. If the boiler is allowed to cool with a fire in the grates, and any condensation of the vapors occurs, as these vapors are heavily charged with sulphuric and other related acids, corrosion or "pinholing" takes place, which soon works its way through the metal plates. The fire should be pulled out before the boiler is allowed to cool. If the draft is good no difficulty is encountered in burning sufficient fuel to produce the quantity of steam desired. While the Clarion is not rated a good steam coal, if properly handled, the results are satisfactory.

The objections to the Clarion coal for brick burning are the action of the eliminated sulphur gases on the ware, the short flame produced, and the sluggish burning of the fuel on account of light drafts. The acid constituents of the gases by attacking the clay components produce more or less salts on the surface of the ware, especially during the early stages of burning, which gives a dull and often unsightly appearance to the finished product. The knitting or cementing of the particles, and the surface finish of clay ware, is considerably influenced by the direct impinging of the flame; hence long-flamed coals are more desirable than the short-flamed varieties. This is the case especially for burning high-grade face brick.

The high sulphur content eliminates the Clarion coal from most metallurgical operations. Although the coal has good coking qualities, the sulphur remaining in the product after coking is far above the standard limit demanded by the trade. If used in the form of producer gas special treatment with ferric oxide or other absorbents for the elimination of this element would be necessary. For domestic use the main objection, especially if burned in open grates or stoves, is the sulphur fumes thrown off which attack the tissues of the throat and lungs.

Another undesirable feature is the soot produced which soon clogs the flue system.

The sulphur in the Clarion coal occurs principally in the form of iron sulphide as pyrite or marcasite, but a part is combined with the organic matter as organic sulphides. A thorough process of breaking and washing would remove a considerable part of the metallic sulphide, as it occurs mainly in lenticular layers and nodules. It is especially concentrated in the thin lower parting and in the coal near it. Washing would have no appreciable effect in lowering the organic sulphur content.

Economic Value of Clarion Clay

The Clarion clay in Jackson County has little value. In most of the area the sandstone below lies close to the coal, so the average thickness of the clay is only 2 or 3 feet. In a few localities it is somewhat thicker. The clay is siliceous, and normally it contains enough fluxing impurities to impair its value for refractory wares. It is best suited for the manufacture of building brick. It is not likely that the Clarion clay will be utilized to any considerable extent, as the Lower Kittanning clay above is much thicker and of better quality.

FERRIFEROUS LIMESTONE AND ORE

The next members of value in the ascending scale are the Ferriferous or Vanport limestone, and the Ferriferous or Baird ore. They are directly associated, seldom more than a bedding plane or an inch or two of shale separating the two. The Ferriferous ore was the main reliance of the old charcoal furnaces, and is used at present (1916) by Jefferson Furnace, the only charcoal stack in the state in blast. The Ferriferous limestone was the principal source of flux stone for the charcoal furnaces, and is used some at present by the modern furnaces in the region. The history of the iron industry in the Hanging Rock District, both past and present, is interwoven with descriptions or references to these members. The Ferriferous limestone and the Ferriferous ore are found in a very small area in Hamilton Township, but they extend along the main ridges over most of Jefferson Township. The areas in which the members are present in the eastern parts of Franklin, Lick, and Coal townships are also very small. These beds are represented in force, however, in Madison, Bloomfield, and Milton townships. The following pages give a more detailed description of the areas, but contain only a few records, as many measurements in which the thickness of the beds are shown have already been given.

Extent and Stratigraphy

Hamilton Township—The Ferriferous limestone and ore are found in Hamilton Township only in Section 36, where the beds are exposed near the summit of the main ridge in the extreme southeastern part. The limestone, which is from 5 to 7 feet in thickness, is generally flinty in character.

Jefferson Township.—In Jefferson Township the limestone and ore are present in 24 of the 36 sections, being absent in 8 sections in the northwestern part. These members are found near the summits of the main ridge and spurs running northeast from Section 31 to Jefferson Furnace, in Section 14. In the eastern part of the township the horizon lies about half way up the hills, thus increasing the area of the deposits. At the mines of the Washington Coal Company near Monroe, the limestone has good thickness, but the ore is reported generally thin. The section taken at the mine follows:

	Ft.	In.
Ore, *Ferriferous*	--	3
Limestone, *Ferriferous*	7	--
Shale	--	4

		Ft.	In.
Coal	*Clarion*	1	--
Clay		--	5
Coal		1	6
Clay, sulphur band		--	1
Coal		--	6

On land of the Diamond Brick Company, Section 25, the strata measured as follows:

	Ft.	In.
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*	7	--
Coal and partings, *Clarion*	4	9

On the land of the Jefferson Iron Company near Mt. Horeb Church, in Section 15, the ore is being mined for furnace use. The section taken follows:

	Ft.	In.
Ore, *Ferriferous*	--	10
Limestone, *Ferriferous*	5	--
Coal blossom, *Clarion*	3	--

Madison Township.—The Ferriferous limestone and ore are found well above drainage in the western part of Madison Township, but owing to the dip eastward they pass under cover near the central part. As no drill records are available the condition of the members in the covered area embracing sections 1, 2, 11, 12, 13, 14, 23, 24, 25, 26, 27, 28, 33, 34, 35, 36, and sections 1, 2, and 3 south are not definitely known, but both beds are somewhat steady where they disappear below cover. In Section 6, on the land of Margaret Evans, the following rocks were measured:

	Ft.	In.
Ore, *Ferriferous,* reported thickness	--	3
Limestone, *Ferriferous*	6	--
Coal and parting, *Clarion*	3	4

In the northwestern part of the township, in small areas, both the limestone and ore are wanting, while at other places only the ore is present. This condition, where the limestone is absent, but the ore considerably thickened, is shown in the following section, taken on land of F. H. Quick, near the center of Section 7:

	Ft.	In.
Ore, *Ferriferous*	1	6
Coal, *Clarion,* reported thickness	2	6

In the northern part of the section on the same property the ore measured only 3 inches, while the limestone had a normal development. Near Madison Furnace, in Section 5, the thickness of the limestone is 7 feet, and of the ore 10 inches. The Ferriferous limestone and ore are usually present, but are often flinty in character in sections 3 and 4. The thickness of the limestone observed along the outcrop is from 5 to 7 feet, while that of the ore is from 2 to 10 inches. These conditions also hold true in sections 9 and 10. On the average the beds are somewhat thicker in sections 16, 17, and 18, but locally the limestone may be flinty in character. The following measurements illustrating the members when in good volume were taken along the road east of Moriah Church, in Section 16:

	Ft.	In.
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*, part flinty	10	--
Coal and partings, *Clarion*	4	--

In the western part of Section 19, on the land of Arizona E. and Myrta L. Evans, the kidney ore in the shales above the Ferriferous ore was noted. This ore is found in many places in Lawrence County, but it was seldom observed in Jackson County. The section which follows shows its position:

		Ft.	In.
Ore, kidney		--	4
Shale		3	--
Ore, *Ferriferous*		--	10
Flint	*Ferriferous*	--	10
Limestone		5	--

The usual thickness of the Ferriferous limestone, where observed in sections 20, 21, and 22, is from 5 to 7 feet, but in some localities it is flinty, while in restricted areas it is wanting. The thickness of the ore where exposed for measurement was from 3 to 10 inches. Both limestone and ore are quite steady in sections 31, 32, and sections 4, 5, and 6 south.

Franklin Township.—The Ferriferous limestone and ore in Franklin Township are found only near the summits of the high ridges and hills east of the Franklin Valley. In the southern part of this territory they are found in sections 23, 24, 25, 26, 35, and 36. On the property of Albert Evans, in Section 36, the limestone exposed on the outcrop measured as given below:

	Ft.	In.
Limestone, *Ferriferous*, somewhat weathered, very flinty	3	--
Clay shale, soft	2	--
Coal and partings, *Clarion*	4	--

On the property of James A. Hensen, in Section 23, the exposure of limestone and ore was measured with the following results:

	Ft.	In.
Ore, *Ferriferous*	--	5
Limestone, *Ferriferous*	7	--
Coal and partings, *Clarion*	4	--

A small area of flinty limestone was found near the summit of the ridge in the southern part of Section 2, but no measurements were made. In Section 1 small patches of limestone and ore were found, but the members are unsteady, as they are partially replaced by heavy sandstones.

Bloomfield Township.—The Ferriferous limestone and ore are well represented in Bloomfield Township, where the latter was formerly extensively worked for the charcoal furnaces. In the western part of the township the beds are found near the 800 foot contour. In the southern part they dip below drainage along the headwaters of the eastern tributaries of Symmes Creek, but in the northern part they disappear along the course of Little Raccoon Creek south of old Keystone Furnace. A few sections showing the thickness of the limestone and ore, measured where best exposed along the outcrop, will be given. A record obtained at old Limestone Furnace, in Section 32, is given below:

	Ft.	In.
Ore, *Ferriferous*, formerly mined, not seen.		
Limestone, *Ferriferous*	7	--
Coal, *Clarion*	4	4

In Section 29 the Ferriferous limestone and ore have good volume. The general thickness of the limestone is from 5 to 8 feet, while that of the ore is from 2 to 10 inches. These members pass below drainage in the western parts of sections 28 and 33, and in the northern part of Section 27. They are completely covered in sections 24, 25, 26, 34, 35, and 36. The following record obtained on the land of the Southern Ohio Portland Cement Company, in Section 20, shows the character of the beds in this locality.

	Ft.	In.
Ore, *Ferriferous*	1	--
Limestone, *Ferriferous*	7	--
Coal and partings, *Clarion*	4	5

In this locality the ore has excellent volume in restricted areas as it thickens to 2 feet 6 inches. In sections 16, 17, 21, and 22, the limestone is from 6 to 8 feet in thickness, and is quite persistent. The ore usually measures from 2 to 8 inches, but it often exceeds this. The rocks noted on the land of Taylor Munyon show good development of the limestone and ore. The record follows:

	Ft.	In.
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*	7	--
Shale	--	4
Coal and partings, *Clarion*	4	10

In sections 13, 14, and 23, the Ferriferous limestone and ore are rather unsteady, although both are well developed in local areas.

Only small pockets of limestone and ore are found on the highest knobs in sections 30, 19, 18, 7, and 6, and in sections 5 and 8 the areas are not large, and, where exposed, the limestone is usually somewhat flinty. The members are thin or wanting in parts of Section 4, but have medium thickness in Section 9. On land of Anna Dillinger, in Section 3, the rocks exposed gave the following measurements:

	Ft.	In.
Ore, *Ferriferous*	--	5
Limestone, *Ferriferous*	7	--

	Ft.	In.
Shale	--	2
Coal and partings, *Clarion*	4	4

On land of the Superior Colliery Company, in the same section, the limestone on the outcrop measured 7 feet in thickness, and under heavy cover it is reported to reach 10 feet, while the ore varies from an inch or two to over 1 foot, but it has an average measurement of about 6 inches. The heavy sandstone above replaces both ore and limestone in parts of sections 2 and 11, but, when present, the members have about the normal development. A section taken on land of W. L. Perkins, Jr., in Section 11, is given below:

	Ft.	In.
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*	6	6
Shale	--	6
Coal blossom, *Clarion*	4	--

In sections 1 and 12 the limestone and ore are quite unsteady. At many places they are completely wanting, while in some localities the coal below has also been replaced by sandstone.

Lick Township.—The Ferriferous ore and limestone in Lick Township are confined to the high hills and ridges in the eastern part. The areas are generally small. Owing to shallow cover in much of the area the limestone is considerably weathered, but the ore has good thickness and quality. The members are confined to sections 13, 14, 23, 24, 25, 26, 35, and 36. On the land of Luther D. Johnson, in Section 35, the following measurement was taken:

		Ft.	In.
Flint	*Ferriferous*	--	6
Limestone, flint and ferruginous clay		1	--
Shale, dark		1	4
Coal, *Clarion*, seen		3	--

Coal Township.—In sections 11 and 12, Coal Township, near the Walnut Grove School, the horizon is represented by thin, flinty, irregular pockets of limestone with nodular ore. The Ferriferous limestone and ore were not found in Washington Township.

Milton Township.—The beds are valuable again in Milton Township, for the Ferriferous ore or limestone is represented in every section except 6 and 31. They were extensively used during the early period of iron making in Milton Township by the charcoal furnaces Jackson, Latrobe, Buckeye, Cornelia, and Lincoln, and also later by the coal and coke furnaces Eliza, Milton, and Wellston, but at present neither the ore nor the limestone is regularly used. In Section 29, near Latrobe Furnace, the ore is reported to vary in thickness from 2 inches to 1 foot 6 inches, but to average from 5 to 8 inches. The limestone is from 5 to 7 feet in thickness, but in some localities the upper part is very flinty. This character is shown in the following section, which was taken at the mouth of a coal mine just south of the old furnace:

		Ft.	In.
Flint	*Ferriferous*	1	6
Limestone, good		3	--
Shale		1	5
Coal and partings, *Clarion*		4	11

Along Tarcamp Creek, in sections 28, 33, and 34, the members are quite unsteady, but the ore is more persistent than the limestone, and this condition was found also in Section 35. On Greasy Run, in Section 36, on the land of the Superior Colliery Company, the rocks exposed and measured are given in the following section:

	Ft.	In.
Sandstone, shaly	20	--
Limestone, *Ferriferous*	8	--
Coal and partings, *Clarion*	4	11

In sections 25, 26, and 27, in some localities the massive overlying sandstone replaces the limestone and ore. Along the road west of Little Raccoon Creek, in Section 26, near Buckeye Furnace, the thickness of the beds observed is as given below:

	Ft.	In.
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*	5	6
Coal and partings, *Clarion*	5	--

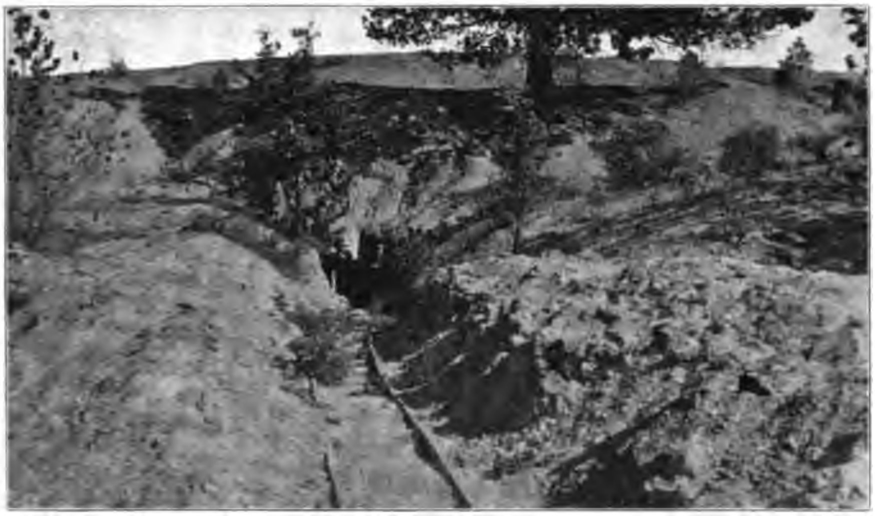
In sections 17, 18, 19, and 20, the upper part of the limestone deposit is often flinty in character, while in local areas the member is thin or wanting. The ore was mined along the outcrop for the charcoal furnaces, but is reported to have an average thickness of about 6 or 8 inches. On land of V. A. Pettinger, in Section 17, the limestone has about its normal thickness, and is of good quality. The record obtained follows:

	Ft.	In.
Ore, *Ferriferous*, reported thickness	--	5
Limestone, *Ferriferous*	6	--
Shale	1	6
Coal and partings, *Clarion*	4	6

This flinty phase of the Ferriferous limestone is also noticeable in sections 16 and 21. On the land of J. H. Scurlock, in Section 16, the limestone member, where exposed for measurement, gave the following record:

		Ft.	In.
Flint	*Ferriferous*	2	3
Limestone		3	5
Shale		1	8
Coal and partings, *Clarion*		4	3

In sections 15 and 22 the members are again somewhat unsteady; further when present the limestone is often flinty in character. East



A.—Ferriferous ore mine near Jefferson Furnace, Jackson County, with a roof of Lower Kittanning clay.

B.—Fire brick plant at Oak Hill, Jackson County.

of this in sections 14 and 23 the beds are seldom present. There is a belt extending from near Keystone Furnace northward to Lincoln Furnace, in which the Ferriferous limestone and ore are very uncertain, for the beds in much of the area are partially or completely replaced by massive sandstone, the thickness of which varies from 10 to 50 feet. In some local areas this sandstone lies unconformably on the Clarion or Hecla below, thus replacing the Clarion coal also. In Section 24, along Buffer Run, the members are somewhat more persistent, which is the case also along the headwaters of Rich Run, in sections 12 and 13. Near the No. 10 mine of the Superior Colliery Company the following measurements were obtained:

		Ft.	In.
Ore, *Ferriferous*		--	4
Limestone, flinty	*Ferriferous*	1	--
Limestone, good		4	--
Shale		2	6
Coal and partings, *Clarion*		4	4

Along Rich Run, in Section 11, the Ferriferous ore and limestone are generally wanting. In the northern part of Section 2, on the land of the Valley Coal Company, the members were exposed for measurement, and the record taken follows:

	Ft.	In.
Ore, *Ferriferous*	--	5
Limestone, *Ferriferous*	6	8
Shale	2	4
Coal and partings, *Clarion*	4	6

In Section 10 only a few pockets of limestone and ore were seen' while the members are also unsteady in Section 3. On the land of Adam Phillips, in the latter sections, the members are present, and measured as follows:

	Ft.	In.
Ore, *Ferriferous*	--	5
Limestone, *Ferriferous*	6	--
Shales	2	6
Coal and partings, *Clarion*	4	5

West of this in sections 4, 5, 6, 7, 8, and 9, the members are quite persistent, but, as they are found high on the hills, the areas are small and the limestone usually much weathered. On a knob on the land of Jacob L. Tucker, in Section 9, the ore and limestone were exposed, and the following section was obtained:

		Ft.	In.
Ore, *Ferriferous*		--	4
Limestone, flinty	*Ferriferous*	1	--
Limestone, good		4	--
Shales		2	5
Coal and partings, *Clarion*		4	9

The members are wanting in Section 31, and the areas are small in Section 32, but on the main ridge in the northern part of this section the ore was formerly mined by stripping, and the limestone, where exposed, measured from 5 to 6 feet in thickness. In Section 33 the members are about normally represented for the limestone is from 5 to 7 feet in thickness, and the ore, where exposed, from 4 to 8 inches. Along the road in the western part of Section 34 the limestone exposed measured 5 feet in thickness, but it is probably thicker under cover. At the mine of the Minglewood Coal Company there is a local thickening of the ore, which in places is reported to reach 2 feet, while the limestone below is normal. The rocks exposed along the outcrop gave the following measurements:

	Ft.	In.
Ore, *Ferriferous*	1.	6
Limestone, *Ferriferous*	5	--
Shale	2	--
Coal and partings, *Clarion*	3	6

In Section 35 the limestone and ore are again uncertain, for they are often replaced by sandstone. The horizon drops below drainage along Mulga Run in the central part of Section 36, but here the massive sandstone above lies directly on the Clarion coal, having thus replaced both ore and limestone.

Economic Value of Ferriferous Limestone

The Ferriferous limestone, although worked but little at present in Jackson County, is an asset of value, as this is the only deposit of limestone in the region which covers a large area, and has good thickness and quality. Moreover, the association of the limestone with the ore and Clarion coal are features of importance. The bed varies in thickness from about 2 to 10 feet, but the average measurement is about 6 feet. The member in the southern part of the county is very persistent, being found, with few exceptions, on the horizon, while in the northern part it is quite steady, with the exception of an area extending along the valleys of Little Raccoon Creek and Mulga Run from Keystone Furnace to Lincoln Furnace. In this region it is often completely replaced by massive sandstone, which in local areas has also replaced the Clarion coal below.

Analyses of Ferriferous Limestone from Jackson County, Collected from Various Sources

Sample.	No. 1.	No. 2.	No. 3.	No. 4.
Silica, SiO_2	1.00	1.00	13.62	3.00
Ferric oxide, Fe_2O_3 Alumina, Al_2O_3	6.80	1.00	2.45	3.48
Calcium carbonate, $CaCO_3$	88.80	94.20	82.30	91.04
Magnesium carbonate, $MgCO_3$	1.20	.76	.82	1.30
Water, hydroscopic	1.80	2.90	----	----

Sample No. 1, Gray or Ferriferous limestone, lower part. Locality not designated. Geol. Surv. Ohio, Rep. of Prog., 1870, p. 152

Sample No. 2, Gray or Ferriferous limestone, upper part. Locality not designated. Geol. Surv. Ohio, Rep. of Prog., 1870, p. 152.

Sample No. 3, Kitchen Station, Geol. Surv. Ohio, Bul. 4, Fourth Ser., 1906, p. 83. Limestone in upper part of deposit flinty.

Sample No. 4, Cornelia Furnace, Geol. Surv. Ohio, Bul. 4, Fourth Ser., 1906, p. 83.

The Ferriferous limestone is well fitted for the manufacture of Portland cement. This fact is established by the quality of the cement produced both by the Lawrence County plants, and by those plants that formerly operated in Jackson County, but which at present are idle or abandoned, although this is not due to the effects of the quality of the limestone. The usual variation in the composition is about as follows:

Silica, SiO_2	1.00 to 5.00 per cent.
Alumina, Al_2O_3	1.00 to 3.00
Ferric oxide, Fe_2O_3	1.00 to 3.00
Calcium carbonate, $CaCO_3$	88.00 to 94.00
Magnesium carbonate, $MgCO_3$	.50 to 3.00
Sulphur, S	.20 to .60
Phosphorus, P	.07 to .12

The general qualities of the limestone for cement have been treated in the report on Lawrence County; hence they will not be discussed further. The high content of lime and magnesia makes the Ferriferous limestone desirable for metallurgical purposes, and it compares favorably with other flux stones used in this state. The charcoal furnaces in the region used it almost exclusively, and the present coke furnaces draw a part of their supply from this source.

The suitability of the stone for road building is attested by the fine macadam roads in the county, which are solid and durable. The stone is dense, tough, and non-slaking, while the fine materials produced have cementing properties which bind the parts into a stable mass. The Ferriferous limestone in some quantity is found in six townships in the eastern part of the county. The usual method pursued is to quarry the stone, and then to haul it to a place only a mile or two distant along the road under construction, where it is reduced by portable crushers and then distributed by teams. The cost of building roads under these conditions is low. The six townships not thus favored with deposits of Ferriferous limestone rely somewhat on local sandstones or conglomerate, but mainly on that hauled by wagon from the nearest Ferriferous outcrop, or on that supplied by rail. It is also the principal stone used for concrete work in building bridges and culverts. Thus it is the main material used in the construction of the Jackson County pikes, the excellence of which demonstrates the quality of the stone.

Another use of limestone that is growing in importance each year is for agricultural purposes. The soils derived from the weathering of the Allegheny and of the Pottsville rocks are deficient in this ingredient, as is attested by the difficulty with which clover is grown. Lime is necessary for plant growth, especially for those of the leguminous types. The composition of the Ferriferous limestone is such that it is well fitted for agricultural purposes; therefore, establishments preparing it for the trade should be encouraged, for a part of the product could be used at home with good results. In general the lands in Scioto, Pike, and Vinton counties are also poor in this ingredient. In eastern Jackson County the natural conditions are very favorable for the establishment of lime plants, while the shipping facilities are such that a large area may be reached with ease.

The association of the Ferriferous limestone and Clarion coal is a relation of importance in mining, as both coal and limestone may be removed from the same workings. The method of attack is to mine the coal, and then shoot down all or part of the limestone above. If the material overlying the limestone is a thick sandstone or a tough shale, the full thickness of the limestone deposit is worked. If this is a soft clay or a tender shale, 1 to 2 feet of stone are allowed to remain to form the roof of the mine. The usual method practised, where the deposit is 7 or more feet in thickness, is to mine about 5 feet, which, with the coal below, gives workings from 9 to 10 feet in height.

In parts of Jackson County there is a massive sandstone above the limestone which will thus allow the full thickness of the latter to be mined along with the Clarion coal below. The association of the Ferriferous limestone and ore is of less importance, but if the full thickness of the limestone is mined the ore is obtained at a low cost.

Economic Value of Ferriferous Ore

The rich Ferriferous ore has been of vast importance in establishing the iron and steel industry in this state. It was the main dependence of about 100 charcoal furnaces in the Hanging Rock District, of which 16 were in Jackson County. The thickness of the deposit, the yield of metal, the excellent working qualities in the short stacks of the charcoal furnaces, and the natural composition for smelting foundry iron, placed this ore at the head of the list of native ores in importance. The ore varies in thickness from one inch to as much as 2 feet 6 inches, but the usual measurement is from 5 to 12 inches. The exceptional volumes noted are usually of local extent, somewhat in the nature of rolls, and they usually denote a decrease in the normal thickness in the surrounding areas. Under heavy cover the ore is of the normal carbonate type, but along the outcrop it has weathered to the hydrate forms with an increase in the iron content. The usual outcrop ore is porous blocks, but under extreme weathering it is soft and clay-like in character; especially is this the case in that found along the joint planes where the limestone below has weathered to widely separated blocks. This ore more nearly resembles colloidal precipitated hydrates.

The Quality of the Ferriferous Ore is Shown by the Following Analyses Collected from Various Sources

Sample	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Specific gravity—dried at 212°	2.980	2.868	2.983	2.704	4.872	3.375	3.245	
Water combined	10.40	11.90	7.40	11.10	3.25	3.33	3.20	-----
Siliceous matter, SiO_2, etc	5.84	1.62	3.44	23.64	31.56	8.84	23.36	20.90
Iron sesquioxide, Fe_2O_3	79.40	72.61	87.89	62.69	13.55	13.91	13.16	-----
Iron carbonate, $FeCO_3$	-----	-----	-----	-----	34.01	55.99	48.44	-----
Iron, metallic, Fe	55.58	50.83	61.52	43.88	25.91	36.77	32.59	38.10
Alumina, Al_2O_3	.40	.40	-----	-----	2.60	.30	.80	6.43
Manganese, Mn	1.90	1.05	.10	.07	.45	.55	.25	.67
Calcium carbonate, $CaCO_3$	-----	-----	-----	trace	9.25	4.70	4.90	-----
Lime, CaO	.40	9.75	trace	trace	5.18	2.63	2.74	2.15
Magnesia, MgO	.68	1.59	.62	.75	1.40	2.38	.81	trace
Phosphoric acid, P_2O_5	.642	.466	.414	.754	.894	.530	.065	-----
Phosphorus, P	.280	.203	.181	.329	.390	.231	.027	.134
Sulphur, S	.12	.14	trace	trace	.12	2.72	.16	-----
Sulphuric acid, H_2SO_4	-----	-----	-----	-----	-----	8.33	-----	-----
Water, hydroscopic	-----	-----	-----	-----	-----	-----	-----	7.00

No. 1, labeled "Best limestone ore," Geol. Surv. Ohio, Report of Progress, 1870, page 137.

No. 2, labeled "Good limestone ore," Geol. Surv. Ohio, Report of Progress, 1870, page 137.

No. 3, labeled "Dark red limestone ore," Geol. Surv. Ohio, Report of Progress, 1870, page 137.

No. 4, labeled "Limestone ore, reddish gray, shaly," Geol. Surv. Ohio, Report of Progress, 1870, page 137.

No. 5, labeled "Limestone ore, blue carbonate, best quality," Geol. Surv. Ohio, Report of Progress, 1870, page 137.

No. 6, labeled "Limestone ore, blue carbonate, earthy, sulphurous," Geol. Surv. Ohio, Report of Progress, 1870, page 137.

No. 7, labeled "Gray limestone ore," Geol. Surv. Ohio, Report of Progress, 1870, page 137.

No. 8, average analysis of Ferriferous ore, reported by the Jackson Iron and Steel Co., Jackson, Ohio.

Owing to the thinness of the deposit, and to the more desirable quality of the weathered product, the Ferriferous ore has been mined mainly by stripping along the outcrop. In local areas where the thickness is exceptional, and the quality good, it has been mined by drifting. At present both methods are used to obtain the ore supply for Jefferson Furnace. Small amounts are also obtained from the limestone mines.

LOWER KITTANING COAL, CLAY, AND SHALE, AND OAK HILL CLAY

The Lower Kittanning horizon with its coal, clays, and shales, is of great importance at present in Jackson County, and in the future it may lead to increased development. The clays which are by far the most valuable in the area are the basis of the present brick industry at Oak Hill. The shales also have excellent ceramic qualities, although they are but little utilized at present. The Lower Kittanning coal, the main stratigraphic member of the group, has ample thickness for mining in most of the area, while the quality of the fuel for general purposes is next to that of the Quakertown, or Jackson Hill. When the economic values of all the beds on the horizon are considered, the interval is thus seen to furnish valuable natural resources for industries, especially along ceramic lines. See Map III.

Position

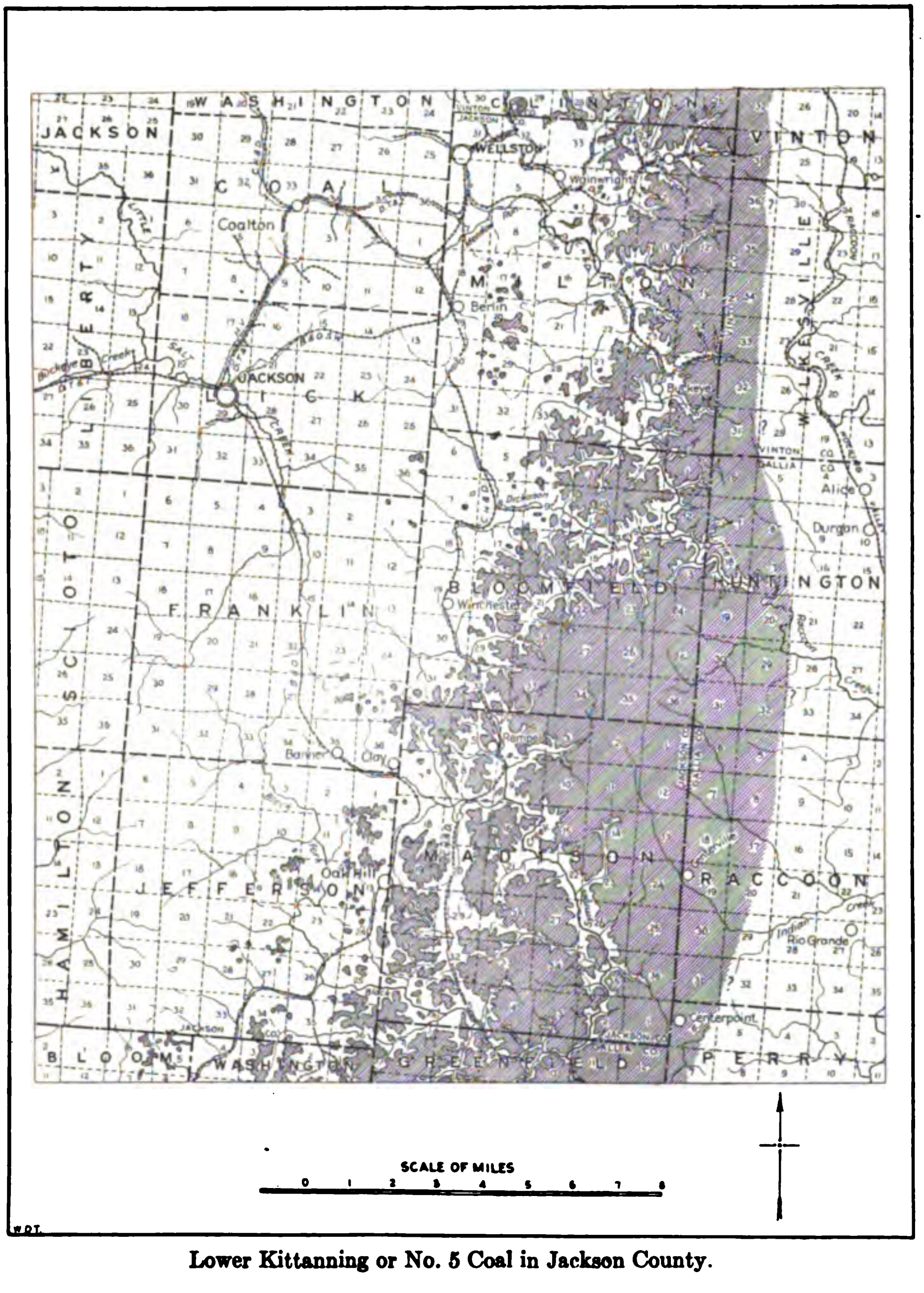
The Lower Kittanning coal is the first coal bed of importance above the Ferriferous limestone. In Jackson County the average interval separating the two members is 25 feet, although it varies from 13 to 52 feet. It is separated from the overlying Middle Kittanning coal by a series of shales and sandstones with irregular deposits of clays, thin coals, and ores, the total average thickness of which is 39 feet. The interval expands from 21 to 64 feet. The first member of special economic importance above the Lower Kittanning coal is the Oak Hill clay, which in some localities lies directly on the coal, but which at other places may be separated from the coal by as much as 29 feet of shales and sandstones. The average interval of separation is about 5 feet. The Lower Kittanning clay is found directly below the coal member, and it averages 6 feet in thickness, that is, when the clay-bonded sandstone below is not considered a part of the bed. The Red Kidney ore, which is seldom present in Jackson County, lies about 12 feet above the Lower Kittanning coal.

Extent

The Lower Kittanning coal and the associated clays are found in eastern Jefferson Township, but the areas are small, as the horizon rising westward soon passes above the summits of the highest hills. The coal is of value only in the eastern tier of sections, for in those west of this it is badly weathered on account of shallow cover. In Madison Township, where the members are well represented, the total area is large. In the western part of the township the Lower Kittanning coal is found about 800 feet above tide, but owing to the dip eastward it passes below drainage before reaching the eastern boundary.

The members are poorly represented in Franklin Township, for the beds are confined to small areas near the summits of the high knobs in sections 1, 25, 26, and 36, while in Lick Township they were seen in the northeastern part of Section 36 only. They are wanting in Coal and Washington townships. The total area in Bloomfield Township is large, for they are present in all the sections east and south of the old preglacial river, but in those west of this they are practically wanting. Milton Township is well supplied with Lower Kittanning

MAP III.



Lower Kittanning or No. 5 Coal in Jackson County.

coal and associated minerals, but the areas of most importance are in the eastern half of the township.

The total area of Lower Kittanning coal in Jackson County is about 58 square miles. Owing to many wants and thin places the area in which the bed has a thickness of 2 feet 6 inches or more is estimated to be approximately 25 square miles. Since a part of this good territory has been worked for local use and railroad shipment the area yet available will scarcely exceed 20 square miles

Stratigraphy

The Lower Kittanning horizon will be treated as a unit. Specific and general sections showing the structure and relations of coals, clays, and shales will be given in order to avoid repetition of the measurements. The Lower Kittanning coal and clay are quite persistent, seldom being absent where due, although in local areas they may be somewhat changed or thinned. The Oak Hill clay above extends across the county, but in many localities it is replaced by a heavy coarse-grained sandstone, the lower part of which is often conglomeratic. In the shales above the Lower Kittanning coal in the northern part of Milton Township, other thin coal beds are found which appear to correlate with the Lost Seam of Lawrence County. All these features will be illustrated in the following sections, as well as the relation of these beds to various members higher and lower in the geological scale.

Jefferson Township.—In Jefferson Township the productive areas are confined mainly to the eastern tier of sections. At the mines of the Washington Coal Company, Section 34, the following relations were noted.

	Ft.	In.
Coal blossom, *Lower Kittanning* or *No. 5*	2	--
Clay, light, plastic, good	7	--
Clay, sandy, ferruginous	2	--
Shale	16	--
Ore, *Ferriferous*	--	3
Limestone, *Ferriferous*	7	--

Just north of the old stack of Cambria Furnace, Section 36, the strata exposed above the Ferriferous limestone were as follows:

	Ft.	In.
Coal, *Middle Kittanning* or *No. 6*	1	8
Clay	1	--
Shales, part sandy	14	--
Sandstone, massive, irregular	5	--
Shales, brown	3	--
Clay shales with small ore nodules	2	--
Sandstone	3	--
Sandstone, shaly	1	--
Sandstone, massive	9	--
Shales	2	--

		Ft.	In.
Clay, *Oak Hill*, part flinty		1	4
Coal	*Lower Kittanning* or *No. 5*	1	2
Clay		1	6
Coal		--	6
Clay, plastic, good		6	6
Shales		10	--
Covered		2	8
Ore, *Ferriferous*		--	4
Limestone, *Ferriferous*		5	--

A composite section at the mines of the Diamond Brick Company at Oak Hill is as follows:

		Ft.	In.
Clay, dark, ferruginous	*Oak Hill*	--	4
Clay, flint		1	6
Shale with thin coal bands		--	5
Coal	*Lower Kittanning*	1	4
Clay		--	5
Coal		--	7
Clay, dark		1	6
Clay, light		6	--
Sandstone, argillaceous		8	--
Shale, sandy		5	--
Ore, *Ferriferous*		--	4
Limestone, *Ferriferous*		7	--

At the mines of the Wm. E. Dee Clay Products Company the following measurements were taken:

		Ft.	In.
Clay, dark, ferruginous	*Oak Hill*	--	3
Clay, flint		1	8
Bone shale		--	3
Coal	*Lower Kittanning*	1	7
Clay		--	5
Coal		--	6
Clay, dark, plastic		1	10
Clay, light, plastic, lower 2 feet sandy		5	--

The strata exposed along the road near the summit of the hill south of Cub Run, in Section 22, are as follows:

	Ft.	In.
Clay, *Oak Hill*	2	--
Coal blossom, *Lower Kittanning*	3	--
Clay and covered	8	--

On land of Joel Davis west of Oak Hill, in Section 14, the record given below was obtained:

		Ft.	In.
Clay, ferruginous	*Oak Hill*	1	--
Clay, plastic, good		1	--
Clay, flint		2	6
Coal	*Lower Kittanning*, reported thickness	3	--
Clay		--	2
Coal		--	10

Northwest of Oak Hill, in Section 12, the following strata were measured at the mines of the Jackson Coal Company:

		Ft.	In.
Clay, plastic, ferruginous	*Oak Hill*	--	6
Clay, flinty		3	6
Shale		7	--
Coal, *Lower Kittanning*, reported thickness		3	6
Clay		7	--
Covered		16	--
Ore, *Ferriferous*, reported thickness		--	5
Limestone, *Ferriferous*		7	--

On land of Leslie Lloyd, in Section 1, the Lower Kittanning coal measured as follows in a mine well under cover:

		Ft.	In.
Coal	*Lower Kittanning*	2	3
Clay		--	2
Coal		--	8

Madison Township.—The deposits on the Lower Kittanning horizon have been more largely worked in Madison Township than in any other in Jackson County. In the main, the flint and plastic clays, the basis of the Oak Hill brick industry, and the coal for the fuel are drawn from the region adjacent to the village, but in this township. Coal and clays here are well developed, while the direct association of the beds is of aid in producing the raw materials at a low cost. The sections given in the following pages illustrate these features. In Section 6, in the southwestern part of Madison Township, the following relations were observed along the road that leads to the ridge south of Black Fork:

	Ft.	In.
Coal blossom, *Middle Kittanning*	1	--
Shale and covered	17	--
Shale and shaly sandstone	4	--
Sandstone	6	--
Shale	12	--
Shale and clay, *Oak Hill*	6	--
Coal blossom, *Lower Kittanning*	3	--
Clay and part covered	5	--

The Lower Kittanning coal and associated clays are wanting or poorly developed in sections 5, 4, 3, and 2, south. The horizon is below drainage in Section 1. The coal is usually present, but generally thin in Section 32; however, the clays often have good volume. Both coal and clays are poorly represented in most of sections 33, 34, 35, and 36, as they are largely replaced by massive sandstones.

The rocks exposed at the main workings of the Ohio Fire Brick Company, just north of the above, are as given below:

		Ft.	In.
Clay, dark, ferruginous	*Oak Hill*	--	6
Clay, flint		2	--

		Ft.	In.
Bone coal		--	4
Coal	*Lower Kittanning*	1	10
Clay		--	5
Coal		--	8
Clay, light, plastic, lower 4 feet sandy		9	4
Sandstone, light, argillaceous, used		5	10
Shale and sandstone		9	--
Ore, *Ferriferous*		--	4
Limestone, *Ferriferous*		6	--

In the northern part of the same section, at the mines of the Aetna Fire Brick Company, the following measurements were obtained:

		Ft.	In.
Sandstone, shaly		2	10
Clay, dark, ferruginous	*Oak Hill*	1	3
Clay, flint, good		2	--
Bone coal		--	6
Coal	*Lower Kittanning*	2	4
Clay			3
Coal		--	10
Clay, plastic, reported thickness		12	--
Shale		6	--
Ore, *Ferriferous*		--	2

The following section was taken in the mine of the Davis Fire Brick Company, Oak Hill, near the head of the entry:

		Ft.	In.
Coal, bony		--	4
Clay, dark, ferruginous	*Oak Hill*	3	--
Clay, flint, good quality		2	--
Coal	*Lower Kittanning*	1	9
Clay		--	2½
Coal		--	6

In Section 19, at the mines of the Ohio Fire Brick Company, the following measurements were made:

		Ft.	In.
Shale		5	--
Coal	*Lower Kittanning* or *No. 5*	2	6
Clay		--	2
Coal		--	6
Clay light, plastic		3	6
Clay, light, siliceous		2	6

North of the above, and in the same section, on the land of Arizona E. and Myrta L. Evans, the following members were measured:

		Ft.	In.
Clay flint, *Oak Hill*		3	--
Clay shale, dark		--	6
Shale		6	--
Coal	*Lower Kittanning*, reported thickness	3	--
Clay		--	3
Coal		--	10

	Ft.	In.
Clay, plastic, reported thickness	5	--
Sandstone and shale	4	--
Ore, kidney	--	4
Shale	3	--
Ore, *Ferriferous*	--	10

In the eastern part of the section, on land of John D. Thomas, the measurements which were taken follow:

		Ft.	In.
Sandstone, argillaceous		4	--
Clay, with ore nodules	*Oak Hill*	--	7
Clay, flint, good		2	1
Covered		23	--
Shale		11	--
Ore, *Ferriferous*, reported		--	8
Limestone, *Ferriferous*		6	--

At the mines of the Jackson West Virginia Fuel Company the rocks given below were measured or reported by the mine foreman:

		Ft.	In.		Ft.	In.
Clay, flint, *Oak Hill*		2	--	to	2	6
Shale		4	--	to	12	--
Coal	*Lower Kittanning*	2	6	to	3	--
Clay		--	2	to	--	6
Coal		--	9	to	1	--
Clay, seen		2				

The deposits of Lower Kittanning coal and associated clays are somewhat patchy in Section 29, but they are quite steady in Section 20. In the latter section the coal has been mined for local needs on the land of Newton Davis, but no measurements were obtained as the mines were full of water when the region was visited (1915). However, on the farm of Jenkin Edwards the stratum was exposed, and the following record obtained:

		Ft.	In.
Shale		5	--
Coal	*Lower Kittanning*	1	10
Clay		--	8
Coal		--	8
Clay		1	--

In Section 28 the coal and clays are largely replaced by massive sandstones. In sections 21, 22, 23, 26, and 27 the coal and clays are seldom represented in force. In a few localities black carbonaceous shales with thin coal bands interstratified were observed, but at no place was coal of value found. The horizon is below drainage in sections 24 and 25. In Section 18, on the property of Isaac M. Morgan, the Oak Hill clay was exposed as follows:

	Ft.	In.
Sandstone	6	--
Shale, sandy	1	7

		Ft.	In.
Clay, flint, *Oak Hill*		2	3
Shale with ore kidneys		1	--

In Section 6. in the northwest corner of Madison Township, on land of Moses J. Davis, the Lower Kittanning coal has the following structure:

		Ft.	In.
Shale		1	6
Coal	*Lower Kittanning*	2	4
Clay		--	1½
Coal		--	10
Clay		1	--

Along the road and on the adjoining properties south of Zoar Church, in Section 6, the following record was obtained:

		Ft.	In.
Shales		17	--
Coal	*Lower Kittanning*	2	5
Clay		--	1
Coal		--	10
Clay		9	--
Shales and covered		18	--
Limestone, *Ferriferous*, weathered		3	--

The Lower Kittanning coal is mined for railroad shipment in the northern part of Section 5. The record obtained at the Commercial mine of E. O. Roberts is given below:

		Ft.	In.
Sandstone		10	--
Coal	*Lower Kittanning*	2	1
Clay		--	1
Coal		--	10
Clay		3	--

In Section 8 the Lower Kittanning coal has good volume, and the clays are also generally well developed. The coal is mined for fuel and the clays for the manufacture of fire brick by the Pyro Clay Products Company in the northern part of Section 17. The following record showing the thickness and relation of the beds was obtained here:

		Ft.	In.
Clay, *Oak Hill*		3	--
Shale		10	8
Coal	*Lower Kittanning*	--	2
Clay		--	2
Coal		2	2
Clay		--	2
Coal		--	5
Clay, dark, impure		--	5
Clay, light, plastic		4	8
Clay, light, siliceous		4	7

The Lower Kittanning coal has also been mined for local use on the land of W. S. Jones and on that of Evan S. Jones. On the farm of the latter the thickness of the bed is shown in the following record:

		Ft.	In.
Shale		6	--
Coal, bony	*Lower Kittanning*	--	6
Coal, good		2	3
Clay		--	3
Coal		--	6

In the southern part of Section 16 the Lower Kittanning coal and related clays are thin or wanting, but in the northern part they are usually well developed. The following measurements were taken at the Elkhorn mine:

		Ft.	In.
Shale		5	--
Coal	*Lower Kittanning*	2	--
Clay		--	2
Coal		--	10
Clay and shale		13	--
Ore, *Ferriferous*		1	--
Limestone, *Ferriferous*		9	--

The coal and clay deposits on this general horizon are patchy in Section 9, while in Section 4 the coal is usually present, but generally thin. In most of the area the clay below the coal has good volume. The following record made along the road in the central part of the section gives the general relations:

	Ft.	In.
Clay, *Oak Hill*	3	--
Shale	11	6
Coal, *Lower Kittanning*	--	9
Clay, plastic, good	4	9
Shale, sandy	16	--
Limestone, *Ferriferous*	4	--

The interval of the Lower Kittanning coal and clays is taken by massive sandstones in most of Section 15, while in Section 14 patches of good coal are found only in a few localities. The coal has been mined by stripping in the bed of a small branch of Cherry Fork on the land of Charles Evans. The thickness of the coal is reported to vary from 2 feet 6 inches to 4 feet. The impure blossom of the member was noted also at several places along the main stream. These beds are below drainage in sections 1, 2, 11, 12, and 13. The coal is thin or wanting in most of Section 10, but the underlying clay in local areas has good volume. The conditions of the Lower Kittanning coal and associated beds in Section 3 are shown in the following record made near where the bridge crosses Sugar Run:

		Ft.	In.
Clay, dark, with thin coal bands		--	4
Coal, bony	*Lower Kittanning*	--	5
Coal, good		--	8
Clay, plastic, good		5	--

Bloomfield Township.—In Bloomfield Township the Lower Kittanning coal and clay are found where due with but few exceptions, but in the northern part of the region the coal bed is often thin. A massive sandstone, the lower part of which is conglomeratic, replaces the Oak Hill clay, and in local areas part of the upper bench of the underlying coal. The succeeding sections taken in this township illustrate the general character of the members in the interval, and the variations due to changes during the period of deposition. On land of William Reese, in Section 31, the Lower Kittanning coal where measured was 3 feet 3 inches in thickness, with a clay parting of 1 inch. In the southwest corner of the same section, on land of John W. Evans, the thickness shown in a mine was as follows:

		Ft.	In.
Clay with thin coal bands		--	7
Coal	*Lower Kittanning*	2	5
Clay		--	½
Coal		1	--

The Lower Kittanning coal and associated members are wanting in sections 6, 18, and 30, while they are represented by only small areas on the high knobs in sections 5, 7, 8, and 19. The Lower Kittanning coal and clay have about normal development in Section 32, but the Oak Hill clay is seldom present. The following measurements, which show the general relations of the members, was obtained along the road on the line of sections 28 and 33:

		Ft.	In.
Clay, dark, carbonaceous	*Oak Hill*	--	6
Clay, light, good		3	6
Sandstone, massive		13	--
Clay shale, light		1	--
Shale, dark, with coal bands		2	--
Coal blossom, *Lower Kittanning*		2	--
Clay, light, plastic		4	--

Another record taken at the mine of David Jenkins is as given below:

		Ft.	In.
Clay, part flint, *Oak Hill*		1	4
Clay shale, dark, with thin coal bands		5	6
Coal	*Lower Kittanning*	2	6
Clay		--	2
Coal		--	4½
Clay, plastic, light		5	--

The Lower Kittanning coal has been mined for local use on the farm of H. Poor, in Section 29. The thickness of the bed in this locality is reported to be approximately 2 feet 6 inches. In most of Section 28 the Oak Hill clay and often the Lower Kittanning coal are replaced by a massive sandstone. The coal, which has been mined, however, for domestic needs, is reported to be about 2 feet in thickness on the land of Jenkin E. Davis, and also on that of Silas Arthur. In the northern part of Section 27, on the farm of John Fink, the Lower Kittanning coal has excellent volume, while the Oak Hill clay is also well developed. The section follows:

		Ft.	In.
Clay, plastic, dark	*Oak Hill*	1	--
Clay, flint, light		--	11
Clay shale, dark		--	2½
Coal, bony	*Lower Kittanning*	--	6
Clay		--	½
Coal		3	3
Clay, good, light		3	--

The interval of the Lower Kittanning coal and related members is below drainage level in sections 25, 26, 34, 35, and 36. The following record was obtained in Section 20, on the land of the Southern Ohio Portland Cement Company:

		Ft.	In.
Coal	*Lower Kittanning*	2	4
Clay		--	2
Coal		--	10

The areas of the deposits of coal and clay in this interval are small in Section 17, but the beds are usually well represented. In parts of Section 16 the beds are replaced by thick sandstones, although at a few places they have normal development. In most of Section 21 the Lower Kittanning coal is especially well developed, as is shown by the following record, which was obtained on the farm of John Morris:

		Ft.	In.
Shale		2	--
Coal	*Lower Kittanning*	3	1
Clay		--	2
Coal		--	7
Clay		2	--

However, only a short distance west of this, on the land of Clement Baker, where the bed is also mined for domestic use, its volume is considerably less, as is shown by the following measurements:

		Ft.	In.
Shale		2	6
Coal	*Lower Kittanning*	2	3
Clay		--	1½
Coal		--	2½
Clay, light, plastic		3	--

In Section 15 the Lower Kittanning coal is generally thin, but the underlying clay has good volume. The Oak Hill clay in most of the area is wanting. The coal has excellent volume in local areas in Section 22, while the Oak Hill clay is also well developed. The coal bed here assumes a phase which is present in the Etna region in Lawrence County, and in the Coal Run field in Milton Township in Jackson County. The thickness of the member is increased by the addition of a third coal bench above the normal deposit, which consists of two coal benches, separated by a clay parting. This extra coal bench is usually impure, although, in the main, in part of the areas in which it is present it contains sufficient combustible matter for use in steam making, brick burning, and other inferior purposes. The structure of the bed, noted in a mine near the residence of Opal Hawker, in Section 22, is given in the following record:

		Ft.	In.
Clay, part flint, *Oak Hill*		2	--
Clay shale, black		--	.3
Coal, bony	*Lower Kittanning*	1	2
Clay		--	¼
Coal, good		2	11
Clay		--	2½
Coal, good		--	9
Clay		2	--

On the land of John Galbroth, in the same section, the Lower Kittanning coal is also mined for local domestic needs, and has abnormal volume, owing to a local expansion of the main coal bench. The measurements taken at this place are given below:

		Ft.	In.
Clay, part flint, *Oak Hill*		2	--
Coal, bony	*Lower Kittanning*	--	4
Coal, good		3	8
Clay		--	1
Coal		--	6
Clay		1	--

This coal has been mined for local use on the farm of Arthur Metcalf, who reports the bed to be about 4 feet in thickness, and to have much the same structure as is shown in the above section. The coal lies 16 feet above the Ferriferous limestone. This thick coal is somewhat local in extent, however, for at other places where the deposit was exposed the bed has normal thickness, or it is even less than this. Along Kyger Run the Lower Kittanning coal goes below drainage in the southern part of Section 23. The bed in this locality is very irregular in thickness, as it is often thinned or replaced by the thick overlying sandstone. Coal has been mined at a few places along the stream, and the bed is reported to be from 2 to 4 feet in thickness. This coal bed has been prospected by drifting on the land of George W. Keeton, in the northern part of Section 24. In Section 14, on the land of C. W. Burris, the coal has been mined by stripping. The deposit is reported to be thin and unsteady. The Lower Kittanning coal and associated clays are poorly developed in sections 12 and 13.

On land of the McKeldon Mining Company, in Section 1, the Lower Kittanning coal, where exposed, measured as follows:

	Ft.	In.
Sandstone, the lower 4 feet with finger coal and pockets of pebbles	12	--
Disconformity.		
Coal, *Lower Kittanning*	1	8
Clay, light, plastic	5	--

On land of the McKeldon Mining Company, in Section 2, the following record was obtained:

		Ft.	In.
Sandstone, with pockets of pebbles		6	--
Coal	*Lower Kittanning*	2	5
Clay		--	1
Coal		--	6

Along the road east of Pattonsville in the southwestern part of Section 3, the Lower Kittanning coal and associated strata were exposed for measurement. The record taken follows:

		Ft.	In.
Sandstone, coarse-grained, lower part conglomeratic		31	--
Coal	*Lower Kittanning*	2	5
Clay		--	1
Coal		--	6
Clay, dark, impure		--	6

North of Goose Run, in the same section, on the land of the Superior Colliery Company, a good surface exposure of the rocks gave these measurements:

		Ft.	In.
Sandstone, lower part with pebbles		65	--
Coal	*Lower Kittanning*	1	5
Clay		--	¼
Coal		--	6
Clay, plastic, good		6	--
Clay, siliceous, good		5	--
Shales, sandy, gray		12	--
Shales, blue		12	--
Ore, *Ferriferous*		--	6

The Lower Kittanning coal in sections 4, 9, and 10 is generally somewhat thin, but the underlying clay has good volume. In most of the area the Oak Hill clay is replaced by conglomeratic sandstones.

Franklin and Lick Townships.—The Lower Kittanning coal is present in a few sections in eastern Franklin Township, but as the cover is shallow the coal is of little value. The member was found only in Section 36 in Lick Township, and it is wanting in Coal and Washington.

Milton Township.—In Milton Township the Lower Kittanning coal is mined for railroad shipment. The bed in restricted areas reaches its maximum thickness in Jackson County, although the upper part is somewhat bony. The clay below the coal has good thickness and is of excellent quality, but it has not been utilized for ceramic purposes. The Oak Hill clay is also present in part of the region, yet it usually lies some distance above the Lower Kittanning coal. In Section 36, south, Milton Township, on land of the Superior Colliery Company, the clay has good thickness, as is shown by the following section:

	Ft.	In.
Coal blossom, *Lower Kittanning*	1	--
Clay, part siliceous	7	--
Sandstone, clay-bond, light	5	--

Just across the line in Vinton County the coal bed and the underlying clay were well exposed. The measurements taken are given below:

		Ft.	In.
Sandstone, massive		70	--
Coal	*Lower Kittanning*	2	--
Clay		--	2
Coal		--	3
Clay, plastic		5	--

In Section 25 the rocks exposed along the road east of Buckeye School show the following members:

	Ft.	In.
Coal blossom, *Middle Kittanning* or *No. 6*	2	--
Shale	17	--
Clay, dark, *Oak Hill*	1	--
Shale	2	6
Coal blossom, *Lower Kittanning* or *No. 5*	2	6
Clay, plastic	4	--
Sandstone, light, clay-bond	6	--

A section showing the relation of members from the Tionesta or No. 3b coal to the Upper Freeport or No. 7 coal was obtained along the road that leads from Buckeye Furnace to Hoihouse Ridge, in Section 26. The lower Freeport and Middle Kittanning coals are replaced by the massive sandstone, which, as shown elsewhere, often lies unconformably on the Lower Kittanning coal. The massive sandstone below this coal replaces the Ferriferous ore and limestone in some localities, and often in local areas takes the place of the Clarion coal also. The measurements taken here follow:

	Ft.	In.
Coal blossom, *Upper Freeport* or *No. 7*	1	--
Shale, colored	7	--
Clay, light	1	--
Sandstone, shaly	1	--
Sandstone massive	59	--
Shale and covered	10	--
Sandstone, shaly	4	--
Shale	3	--
Covered	9	--
Coal blossom, *Lower Kittanning* or *No. 5*	1	--
Clay, light	5	--
Sandstone, shaly	24	--
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*, upper 2 feet flinty	5	6
Coal and partings, *Clarion* or *No. 4a*	5	--

	Ft.	In.
Clay and covered	3	--
Sandstone, massive	48	--
Shale, gray	6	--
Shale with coal bands, *Tionesta, No. 3b* horizon	2	--

On Hoihouse Ridge, in Section 27, a heavy blossom of the Lower Kittanning coal was seen, but the true thickness of the bed was not obtained. In Section 20 the members were exposed along the roadside, and the coal appeared thin.

Along Coal Run, in sections 14 and 23, the Lower Kittanning coal is mined for railroad shipment by the Mohawk Coal Company. The general structure of the bed here is much the same as it is in the Etna region in Lawrence County. There the bony layer or "niggerhead" above the main coal benches varies in thickness from an inch or two to 2 feet, but it has an average thickness of about 1 foot. The bone band in the upper bench, generally present here, is a common feature in the Etna region also. The section taken in the Mohawk mine is as follows:

		Ft.	In.
Coal, bony	*Lower Kittanning*	1	1
Coal, good		1	11
Bone band		--	1
Coal, good		1	--
Clay		--	1½
Coal, good		--	7

Here the lower coal bench is reported to measure about 5 inches, while the clay parting above often thins to ½ inch. In Section 24, on Buffer Run, the Lower Kittanning coal is also mined for railroad shipment by the Superior Colliery Company. The general character of the bed in this locality is the same as that noted on Coal Run. The section taken follows:

		Ft.	In.
Coal, somewhat bony	*Lower Kittanning*	1	--
Coal, good		3	--
Clay		--	2
Coal		--	2
Clay		2	6

The total thickness of the upper bench is reported to vary from 3 feet 10 inches to 4 feet 4 inches in thickness, the clay parting from 2 to 4 inches, and the lower coal bench from 2 to 4 inches. The clay below, which is of good quality, is reported to be quite thick. The tough shale above the coal forms a very good roof for mining. Along the road that leads from Rich Run to the ridge east in sections 13 and 14, the following rocks were exposed for measurement:

		Ft.	In.
Clay, dark, impure, flinty	*Oak Hill*	--	8
Clay, flint, good		2	--
Clay, ferruginous		--	4

		Ft.	In.
Shale		9	4
Coal, bony	*Lower Kittanning* or *No. 5*	--	7
Coal, good		2	4
Clay		--	2
Coal		--	3
Clay, light, plastic, good		9	8
Clay, siliceous		3	--
Sandstone, light, clay-bond		9	8
Ore, *Ferriferous*		--	4

At the No. 11 mine of the Superior Colliery Company a carefully measured section shows the following relations:

		Ft.	In.
Clay, dark, impure, plastic	*Oak Hill*	1	--
Clay, light, plastic, good		1	--
Clay, flint, good		2	--
Clay, ferruginous		--	6
Shale, gray		10	8
Shale, dark		--	6
Coal, bony	*Lower Kittanning*	--	8
Coal, good		2	3
Clay		--	3
Coal, good		--	5
Clay, dark, impure		--	6
Clay, light, good		2	--

The upper bench of coal, excluding the bony part, is reported to have a thickness of 3 feet near the center of the hill. The clay parting varies from 2 to 4 inches. In this region the Oak Hill clay above has excellent thickness and quality, while the associated shales are also well fitted for ceramic products. In Section 12, on the land of the Wellston Coal & Brick Company, the following rocks were exposed for measurement:

		Ft.	In.
Clay with large ore nodules	*Oak Hill*	2	--
Clay, flint		2	--
Clay shale		1	--
Shale		1	--
Shale, with thin bands of kidney ore		3	--
Coal, bony	*Lower Kittanning*	--	6
Coal, good		1	8
Clay		--	2
Coal, good		--	4
Clay		1	--

Near the head of the stream, in the same section, the measurements taken are given below:

		Ft.	In.
Clay, weathered part flint, *Oak Hill*		3	--
Shale		16	--
Coal	*Lower Kittanning*	2	4
Clay		--	1
Coal		--	3

A composite section taken from Rich Run to the church, on the ridge north in Section 11, shows the full thickness of the Allegheny rocks and the positions of the most important members. The record follows:

		Ft.	In.
Coal blossom, *Upper Freeport* or *No. 7*		5	--
Clay		1	--
Sandstone, coarse-grained		20	--
Covered		19	--
Clay shale		7	--
Sandstone, shaly		9	--
Sandstone lime-bond, nodular		2	--
Sandstone, shaly		13	--
Clay shale		3	--
Coal blossom		--	3
Clay shale		--	9
Shale and covered		15	--
Coal blossom, *Middle Kittanning*		1	4
Clay shale		1	8
Shale		14	--
Sandstone, shaly		10	--
Covered		5	--
Clay, plastic	*Oak Hill*	2	--
Clay, flint		2	--
Shale, part sandy		29	--
Coal blossom, *Lower Kittanning*		3	--
Clay		5	--
Sandstone, light, clay-bond		10	--
Sandstone, massive		9	--
Shale, black, fissile		1	8
Coal and partings, *Clarion*		4	4
Clay		3	--
Covered		22	--
Coal blossom, *Brookville*		1	--

The Lower Kittanning coal is mined for railroad shipment by the Browne Coal Company, in the northern part of Section 2. The structure of the bed near the head of the entry is as follows:

		Ft.	In.
Shale		4	--
Coal	*Lower Kittanning*	2	6
Clay		--	¾
Coal		--	4
Clay, good		4	--

The bony layer on the upper coal bench is wanting here, while the thickness of this bench is reported to vary from 2 feet 6 inches to 3 feet.

On land of the Geneva Coal & Mining Company, in Section 36, north, the Lower Kittanning coal, where exposed for measurement, gave the following record:

		Ft.	In.
Shale, sandy		16	--
Coal	*Lower Kittanning*	2	--
Clay		--	3
Coal		--	3

In Section 34 the Lower Kittanning coal is mined by the Minglewood Coal Company for railroad shipment. The bed has good thickness, and the coal in the lower benches is of excellent quality. The strata measured are given below:

		Ft.	In.
Coal, with shale bands	*Lower Kittanning*	1	--
Coal, good		2	6
Coal, bony, hard		--	½
Coal, good		--	4
Clay		--	1
Coal, good		--	6
Clay, good		4	--

Character and Economic Value of Lower Kittanning Coal

The Lower Kittanning coal bed is characterized by being made up of two coal benches separated by clay. Both benches are very persistent, but the upper one is much better developed than the lower. In Jackson County the average thickness of the upper bench is about 2 feet 4 inches, while that of the lower is 7 inches. The maximum thickness of the upper bench, including the bony layer in the upper part, is 4 feet, while the minimum of course depends on the amount of erosion that took place preceding the deposition of the conglomeratic sandstone above. In local areas the bed is thinned to a few inches or completely replaced. Normally the lower bench seldom thickens to over 1 foot, while in some localities it measures only 2 inches. The clay parting expands in thickness from one-half inch to 1 foot 6 inches, but it has an average measurement of about 3 inches. The bony part of the upper bench of coal found in eastern Milton and northern Bloomfield townships is much the same in character as that found and similarly placed in the Etna region in Lawrence County. This layer varies in composition somewhat, but it never reaches that of high-grade fuel, while in some localities it is really a carbonaceous shale with thin coal bands.

The Lower Kittanning coal in Jackson County is worked for railroad shipment in Milton Township. In Section 34, north, the Minglewood Coal Company was laying tracks, and otherwise preparing to mine the bed when the region was visited in the summer of 1914. The main entry was then driven preparatory to turning rooms. The mine of the Browne Coal Company is located in Section 2, and is connected by switch to the Detroit, Toledo & Ironton Railway. The mine is electrically equipped throughout. Jeffrey and Goodman machines are used in cutting the coal, while Morgan and Gardner motors are used for hauling. The coal is elevated to the tipple by chain elevators. The electric current is furnished by a 400 ampere dynamo, manufactured by the General Electric Company, and the steam is generated by 150 H. P. tubular boiler. The mine is well equipped throughout. The number of men employed is usually about

80. The Superior Colliery Company has a mine near the head of Rich Run, in Section 13, but it is idle at present (1914). Mine No. 11 of the above mentioned company is located on Buffer Run, in Section 24. It is a level-free mine, with the coal loaded from a tipple. The mine is electrically equipped, using Morgan and Gardner cutting machines and motors. The capacity is 450 tons per day, and the coal is shipped via the Cincinnati, Hamilton & Dayton Railway. The Mohawk Coal Company operate a pick mine on Coal Run, in Section 23. It is level-free, and mule power is used for hauling the coal. The capacity of the mine is 235 tons per day. It is connected by a switch to the branch of the Cincinnati, Hamilton & Dayton Railway. One shipping mine is in operation at present on the Cincinnati, Hamilton & Dayton Railway in Section 5, Madison Township. It is known as the Commercial mine, and is run by E. O. Roberts. The mine is level-free. Mule power is used in hauling the fuel, which is mined by picks. The daily capacity of the mine is about 50 tons.

The usual method of attack in mining is to cut in the soft clay parting, but this method is not followed entirely, for in some mines the cutting is done in the coal. By cutting in the clay, however, coal is saved. In another way this parting is objectionable, as special care is required to keep the mined coal free from admixed clay, which, if allowed to become wet during transit or storage, disintegrates and whitewashes the coal, thus giving it an unsightly appearance. During mining and handling the admixed clay is more or less reduced to fine material. Where the coal is screened the bulk of it goes into the smaller sized grades of fuel, such as egg, nut, and slack, thus leaving the lump reasonably clean. The amount of clay present is seldom sufficient to impair the real fuel value of the coal. The objection is mainly one of appearance and not of quality. The average thickness of the Lower Kittanning bed, taken from all the measurements made in Jackson County, is 2 feet 11 inches of clean coal in the two benches. Since the specific gravity of this coal is about 1.3, the total fuel per acre is approximately 5,160 tons of 2,000 pounds each. The yield in mining per acre, counting only 60 per cent. available, is thus about 3,100 tons. The clays associated with the Lower Kittanning coal give the bed a special value when considered for the basis of ceramic industries. This subject will be treated more fully under clays.

The Lower Kittanning is classed as a coking coal, although it has been but little utilized for this product in Ohio. The sulphur content, and the tender nature of the coal, limit its value for use in the blast furnace in the raw state. It is a free-burning, long-flamed coal, qualities recommending it for the burning of ceramic products, especially where color of the ware is of importance. For this use it ranks next to the Quakertown coal. It is a good domestic coal, as it produces but little soot, and burns to a light powdery ash. For steaming purposes this coal is well recommended, as it has moderate heating value, and the ash forms hard clinkers only where the temperatures in the grates are very high. The ash is clay-like in character, consequently, at high temperatures, it vitrifies in much the same way as clay. The Lower Kittanning coal is an excellent general purpose fuel and its quality is shown by the following analysis:

Sample from mine No. 11, Superior Coal Company, Section 24, Milton Township, Jackson County. Sample taken well under cover and from a fresh face. The sample was a section 5 x 4 inches and was cut by D. D. Condit in November, 1907.

Chemical analysis and calorific value

Ultimate		*Proximate*	
Carbon	66.63	Moisture	8.39(a)
Hydrogen	5.47	Volatile matter	35.18
Oxygen	16.46	Fixed carbon	49.01
Nitrogen	1.37	Ash	7.42
Sulphur	2.65		
Ash	7.42		100.00
	100.00		

Calorific value { 6,772 calories.
12,190 B. t. u.

(a) Moisture in air-dried sample from 2½ to 3 per cent.[1]

From mine and surface exposures noted, the average thickness of the Lower Kittanning coal in Jackson County is sufficient for ease in mining, as the bed, including the 3 inch clay parting, measures 3 feet 2 inches. Usually the roof is a shale, tough and solid, but in some localities, as noted in the stratigraphy, it is a massive sandstone, while at other places the Oak Hill clay lies directly on the coal bed. The shale or sandstone forms a safe roof, but the clay is held only with difficulty. Where both clay and coal are wanted, as is the case in the Oak Hill district, this association is a decided advantage in economy in the mining of both. In Milton Township, while the Oak Hill clay is moderately steady, it usually lies some distance above the coal; hence it is not detrimental in the mining where only the latter is wanted. Where only a foot or two of shale intervenes between the coal and the massive sandstone above, mining is somewhat dangerous, for percolating waters loosen the shale along the contact, and consequently it soon cracks and falls. This condition though is restricted to local areas. In general the roof of the Lower Kittanning coal is considered safe.

Everywhere the floor of the Lower Kittanning coal is clay, which is always plastic, but which in some localities is somewhat siliceous, and, therefore, harder. In dry mines this plastic clay causes no particular trouble, but in wet mines it causes muddy roadways for hauling, insecure footings for posts and tracks, and it requires additional coal to be left in order to prevent "squeezing" from the weight of the overburden.

When the extent and thickness of the bed, the character of the fuel, the general mining conditions of the deposit, and the worth of the associated minerals are carefully considered, the Lower Kittanning coal is one of the valuable mineral assets of Jackson County, and it bids fair to play an important part in the future development of the region.

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[1] Geol. Surv. Ohio, Bull. 9, Fourth Series, p. 191.

LOWER KITTANNING CLAY

The Lower Kittanning clay, when considered from the point of general ceramic utilization, is by far the most important clay bed in Jackson County, for it is well fitted for the manufacture of a variety of products such as stoneware, face brick, sewer pipe, fire proofing, second-grade fire brick, and paving block. In fact, this bed is the basis of a large part of the ceramic industry of the State, the total value of the clay products of which in 1913 was over $38,000,000. Except in the Oak Hill region but little attention has been paid to the value of this clay, although conditions are favorable for the success of such plants in other parts of the county.

Position of the Member

When considered in a general way, the clays in the interval from the Ferriferous ore or limestone to the Lower Kittanning coal form the Lower Kittanning clay member. This is really divided into two clay beds, the upper one of which is directly associated with the Lower Kittanning coal proper, while the lower one belongs to a thin coal stratum which lies about midway in the interval. The upper clay bed is far more steady than the lower one, which is not commonly present in Jackson County, although well developed and quite persistent in the Etna region of Lawrence County. The clays in both beds are much the same in character, and were formed during the same general swamp period that ended with the deposition of the Lower Kittanning coal. Below the upper clay, in a part of the Jackson County field, there is found a light-colored, fine-grained, clay-bonded sandstone, which also has good ceramic qualities. This really belongs to the upper clay bed, but it is too siliceous to be called a clay.

General Features

The clay of most importance lies directly below the Lower Kittanning coal, and, excluding the clay-bonded sandstone, it averages about 6 feet in thickness. The maximum thickness noted in Jackson County was 10 feet and the minimum 2 feet. The clay-bonded sandstone found in only a part of the field usually averages about 5 or 6 feet in thickness, but in local areas it exceeds this considerably, usually at the expense of the clay above. When both clay and clay-bonded sandstone are present the thickness varies from 10 to 15 feet. Because of the direct association of the Lower Kittanning clay and coal, both may be economically mined from the same workings. The average thickness of the two beds is about 9 feet, a convenient height for ease in mining. The usual method of attack is to mine the clay from below the coal until this loosens from the roof, then a light shot near the face brings the coal down. In this way the cost of mining the clay is from 30 to 50 cents per ton, while that of mining the coal is from 50 to 70 cents. Counting only 60 per cent available, the yield per acre for the coal, as shown before, is 3,100 tons of 2,000 pounds each, while that for the clay, where the bed is 6 feet in thickness, is approximately 12,250 tons. Counting 3.5 tons clay per thousand brick this will produce 3,500,000 brick. With good kiln and steam economy one ton of coal will produce the steam for manufacture and the heat for burning 1,000 brick. This shows that only a small amount of additional fuel is required. It makes a vast difference in the amount of revenue brought into the county whether the coal alone is mined and marketed, or whether coal and clay are mined, worked into ceramic products, and then marketed. The average market price of Lower Kittanning coal will not exceed $1.50 per ton at the mine, and is usually below this figure, while the average price of face brick at the works, taken kiln run, is about $12.00 per thousand; hence, calculating on this basis, we get the following results:

Total production per acre of ceramic products,	
3,500 M brick at $12.00 per M	$42,000
400 tons coal at $1.50 per ton	600
Total	$41,400
Total production per acre of coal,	
3,100 tons coal at $1.50 per ton	$4,650

The amount of money thus brought into the county from the sale of the ceramic products is nearly nine times as much as where the coal alone is sold. These features show that the industry should be encouraged, especially when the conditions are as favorable as found in eastern Jackson County. The conditions in the Wellston region are worthy of attention, for the field of clay and coal is large, the shipping facilities good, and the water supply along the Little Raccoon ample for all purposes. Also in this region there is produced a large amount of nut and slack coal, which, thrown directly on the market, brings but little return, but which if used in the manufacture of ceramic ware would yield a fair profit. Some of the bony coal, now thrown over the dump, could also be utilized in this way.

Working Qualities

The working qualities of the Lower Kittanning clay are so well known that little comment needs be made regarding them. It is the standard plastic clay in Ohio. Although the bed in Jackson County is only of medium thickness, the quality of the clay is on a par with that found in other counties, where it forms the basis of important ceramic industries. The general working qualities of the clay are very satisfactory from almost any point of view. The raw clay if allowed to weather goes down to a plastic mass, or if ground and mixed with water it soon develops excellent bonding properties. For some grades of ware the clay is somewhat too plastic, requiring dilution with other materials. The raw clay is readily reduced by any of the common methods of crushing now used in the clay industry. The type of crusher in most general use is the dry-pan, which will reduce from 60 to 100 tons of this clay in 10 hours. The muds produced by pugging or wet-pan tempering flow readily through the dies, seldom laminating or cracking to the extent to produce loss. Green ware, such as brick or small pieces of hollow ware, in which the walls are not especially thin, dries safely, with but little attention in any of the types of waste-heat or steam driers in general use. When large or thin-walled ware, such as blocks or fire-proofing, is dried in the tunnel driers, the temperature must be more carefully regulated, or direct loss of ware ensues. Also strains started here may develop during the burning into cracks. The bonding and drying properties of the Lower Kittanning clay make it one of the standard sewer-pipe clays in Ohio. In this industry the drying is an important item, for often the ware is large, with medium thin walls, and with sockets which are especially liable to crack. Toughness in the green state is also required here, for the ware must be handled both on the drying floor and in the kilns. The burning qualities of the Lower Kittanning clay are excellent, for it matures to a good dense body at about 1,800 or 2,000° F. The vitrification range is long, thus producing but little waste from overburned or underburned ware. The final fusion point of the clay is usually approximately 3,000° F., but it varies considerably from this on account of the variation in the quantities of fluxing ingredients present. The total shrinkage, both drying and fire, is about 1¼ inches per foot. With siliceous clay it is somewhat less than this, while with fat, plastic clay it often reaches 1½ inches per foot. Occasionally it exceeds the latter measurement. The ware stands up well under firing; so at good maturity but little loss is occasioned by warping, twisting, or cracking. The natural color of the body at early maturity is a clear buff, at medium burns it is a light iron-mottled color, while at hard burns it has dark shades. Any of the colors produced are very pleasing and attractive, and they show but little change on weathering. The following analysis of Lower Kittanning clay, made in 1910, by R. C. Purdy, of the Ohio State University, was furnished by the Pyro Clay Products Company:

Silica, SiO_2	56.75
Alumina, Al_2O_3	29.60
Iron oxide, Fe_2O_3	.90

Titanic oxide, TiO_2	1.10
Calcium oxide, CaO	.25
Magnesium oxide, MgO	.06
Sodium oxide, Na_2O	.15
Ignition loss	11.37
	100.18

The light clay-bond sandstone, found below the Lower Kittanning clay in a part of the Jackson field, is a good adjunct to the clay. It is especially valuable for mixing with the clay when a more siliceous body is required, thus correcting shrinkage, porosity, and ease of glazing. It has good working qualities, and it burns to a light buff color. For many grades of ware this should be worked with the clay above. The character of the clay-bonded sandstone is shown by the following analysis, furnished by the Wm. E. Dee Clay Products Company:[1]

Silica, SiO_2	77.08
Alumina, Al_2O_3	14.62
Ferric oxide, Fe_2O_3	1.00
Titanic oxide, TiO_2	1.20
Lime, CaO	.27
Magnesia, MgO	trace.
Alkalies, Na_2O and K_2O	1.50
Ignition loss	4.26
	99.93

This clay-bond sandstone burned to maturity is a dense strong body, very suitable for paving brick. It is also moderately refractory, as its final fusion point is about 3,100° F. When brick are desired to resist the action of acid slags, or to withstand severe abrasion at moderate temperatures, this material may be utilized with excellent results.

The Lower Kittanning clay is well suited for the manufacture of stoneware, sewer-pipe, fire proofing, roofing tile, high-grade face brick, and second-grade fire brick. It may also be used in the production of terra cotta and paving block. The conditions are very favorable in Jackson County for the success of ceramic plants, and the industry should be encouraged. At present there are seven active brick plants in the Oak Hill district which use the Lower Kittanning clay to some extent. However, this clay with the associated shales forms the basis of only one plant, which is that of the Diamond Brick Company, located about one mile south of Oak Hill. The following general description of the plant was furnished by the general manager, Joseph J. Jones:

The Diamond Brick Company was organized on Feb. 27, 1903. The materials used in the manufacture of the different grades of ware are soil, plastic clay, flint clay, and shale. The thickness of the deposits are as follows: soil 5 feet, plastic clay 14 feet, flint clay 3 feet, and shale 10 feet. The total thickness of all beds utilized is usually close to 32 feet. The general equipment of the plant is one 150-H. P. Atlas engine, two 125-H. P. Houston boilers, one American dry pan, one Raymond pug mill, one American auger machine, and one American automatic cutter. The ware from the machines is loaded on steel cars, about 200 of which are used. The ware is dried with steam heat in 14 tunnels and is burned in 7 down-draft kilns which have a capacity of 70,000 each. Clarion coal is used foı fuel. The daily capacity of the plant is three cars of ware which is shipped via the Baltimore & Ohio Southwestern Railroad. The kinds of ware made are hollow brick, fire proofing, fire brick, drain tile, and face brick.

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[1] H. B. Henderson and W. Stout, The Utilization of Ohio Clay-bonded Sandstones for the manufacture of Silica Brick, Trans. American Ceramic Society, Vol. XVIII.

COAL BED BETWEEN THE TWO BENCHES OF LOWER KITTANNING CLAY

There is a thin coal bed found between the two benches of the Lower Kittanning clay where these are present. This coal deserves a passing mention for the underlying clay really belongs to it, and not to the Lower Kittanning above. This thin coal, separating the two clay benches, is quite steady in the Etna region in Lawrence County, where both clay benches are well developed, but it was only occasionally seen in Jackson County. When both benches of clay are present, a few inches of coal may be the only intervening stratum, or the coal with a few feet of shale or sandstone above may separate them. During the swamp period that began soon after the Ferriferous limestone and ore were laid down, the conditions were somewhat changeable. They were locally favorable first for the formation of a clay bed, followed by the deposition of a thin coal above, while in part of the area shale or sandstone was laid down. Then the conditions became more uniform and the Lower Kittanning clay and coal were formed, the steadiness of which has been described elsewhere. The usual thickness of this coal bed, where present, is from 2 to 6 inches, although occasionally it exceeds this, but the thickness at no place where noted in Jackson County was such as to justify mining at present. A measurement taken in Section 35, north, Milton Township, is given below to show the general relations to other members:

		Ft.	In.
Clay, dark, with thin coal bands, *Oak Hill*		3	6
Coal	*Lower Kittanning*	2	3
Clay		--	1
Coal		--	2
Clay		4	6
Sandstone		1	6
Shale		5	9
Coal	Coal bed under discussion	--	4½
Clay		--	½
Coal		--	9
Clay, part dark		2	6

The coal is of interest mainly for its stratigraphic relations, especially with regard to its association with the lower bench of the Lower Kittanning clay.

"LOST SEAM" COAL

Near Center Station, in Lawrence County, there is a coal bed with a maximum thickness of about 3 feet lying only a few feet above the Lower Kittanning coal. This is called locally the "Lost Seam" coal, for the area is very small, and it was not seen elsewhere in the county. In local areas in northern Milton Township, Jackson County, a coal bed appears on the same horizon, but its thickness, where exposed, is only about 1 foot. This bed is correlated with the "Lost Seam" of Lawrence County, mainly on account of the respective positions of both with reference to the Lower Kittanning coal. The stratum denotes local swamp conditions following the deposition of the regular bed below. A section will be given to show its position with reference to other important members. The measurements taken along the road in the northern part of Section 2, Milton Township, follow:

		Ft.	In.
Coal blossom, *Middle Kittanning*		1	3
Shales, part sandy		15	3
Ore, nodular, *Red Kidney*		--	5
Sandstone, shaly		3	3
Clay, dark	*Oak Hill*	1	4
Clay, light		1	4
Clay shale		2	--
Coal blossom, "*Lost Seam*"		1	2
Clay shale		2	2
Coal	*Lower Kittanning*	2	1
Clay		--	1
Coal		--	2

This bed is also found in the shales above the Lower Kittanning coal in the mine of the Browne Coal Company. As the deposit is local and thin, where exposed, it is not economically important. There is a chance, however, that in small areas the bed may be found lying so close to the underlying Lower Kittanning coal that it can be mined along with the latter.

HAMDEN ORE

Near old Hamden Furnace, west of the village of Hamden, in Vinton County, there are found deposits of iron ore which contain a fair percentage of iron, but which are characterized by having an extremely high phosphorus content; this far exceeding the other native ores of the State. Locally the ore is known as the Hamden ore; hence it is so designated in this report. Although this bed was not found well marked in Jackson County there are in a few localities in Milton Township ferruginous deposits which are at the same stratigraphic position as the Hamden bed; therefore, the member will be briefly treated here.

The stratigraphic position of the Hamden ore is above the Lower

Kittanning coal, or more definitely, at the base of the Oak Hill clay. Both the upper and lower surfaces of the deposits are very irregular, and the ore often replaces a part of the clay above. The ore is of swamp origin. The association of ore and clay indicates that it was laid down at the beginning of the swamp period that closed with the deposition of the Oak Hill clay. Along the outcrop the iron is mainly in the form of hydrated oxide; while under deep cover it is combined principally with carbon dioxide as the carbonate, which also indicates swamp deposition.

In the unweathered or carbonate ore the phosphorus is combined principally with lime as calcium phosphate, while in the weathered ore a part of the lime is replaced by iron oxide. The phosphorus content varies considerably in different parts of the bed, being most concentrated in the lower layers. The percentage of metallic phosphorus varies from 2 to 12 per cent, but averages between 4 and 5. The phosphorus pentoxide thus constitutes about one-tenth of the total. The origin of the deposits is a subject of interest, but the discussion will not be attempted until more investigation has been made.

The measurements of the strata obtained on the land of the Puritan Brick Company, in Section 16, Clinton Township, Vinton County, are as given below:

	Ft.	In.
Clay, dark, part flinty, with small, scattered ore nodules, *Oak Hill*	2	6
Ore, *Hamden*	9	--
Covered interval reported	2	--
Coal, *Lower Kittanning*.		

The thickness of the ore is reported to vary from 1 to 12 feet, and to be confined to a very small area.

The ore is of considerable value commercially, both for its iron and for its phosphorus content. Through the kindness of Mr. J. H. Frantz, of the Columbus Iron and Steel Company, the analysis of the ore was obtained. The composition shown by the average analysis of 29 cars of ore is as follows: Percy Daines, analyst.

	Dry 212°	Natural.
Iron, Fe	33.09	28.87
Silica, SiO_2	9.20	8.03
Phosphorus, P	4.78	4.17
Manganese, Mn	.85	.74
Alumina, Al_2O_3	8.37	7.30
Lime, CaO	9.75	8.51
Magnesia, MgO	.90	.79
Ignition loss	11.60	10.12
Moisture	----	12.75

This ore was first used by Hamden Furnace in making charcoal iron, which, owing to the high phosphorus, was very brittle and had a silvery appearance. At present a few furnaces use, along with the Lake ores, small amounts of the Hamden ore to increase the phosphorus content of the burden. Used in this way it is more valuable than the phosphate rock often added for the same purpose. Used alone the ore makes a high phosphorus iron. Under ordinary conditions practically all the phosphorus and about one-half the manganese found in the burden smelts with the iron. With silicon 2 per cent and carbon 4 per cent the approximate composition of iron made from Hamden ore is as follows:

Carbon, C	4.00
Silicon, Si	2.00
Iron, Fe	81.21
Phosphorus, P	11.73
Manganese, Mn	1.06
Total	100.00

The ore is most valuable for metallurgical uses, but, as the amount available is small, its field is greatly restricted.

OAK HILL CLAY

The Oak Hill clay in the vicinity of Oak Hill constitutes the basis of important fire brick works, which represent by far the most valuable industry in Jackson County, depending on the utilization of native raw materials for its support. The clay here has been worked for many years, and the plants are very successful, partially due to good management and partially due to the quality of the material and to the close association of the clay and Lower Kittanning coal. The natural conditions exhibited here are not surpassed elsewhere in southern Ohio for both plastic and flint clay, and coal may be taken from the same mine. The firms enjoy a wide reputation for the quality of their products, and the industry has steadily increased both in the number of plants established and in the general output that each produces.

Stratigraphic Position

In a general sense the Oak Hill clay may be placed in the Lower Kittanning coal interval, but when considered in a more critical way the bed is distinctly separate and unrelated to the coal below, except in so far as the two are often closely associated in position. In local areas in the Oak Hill region the clay lies directly on the coal below, but passing northward the members are usually separated by a number of feet of shales or sandstones, the maximum thickness of which, observed by the writer, was 29 feet. The average interval between the two beds is about 5 feet, but intervals measuring from 5 to 15 feet are common. In fact superimposition of the beds is rather the exception. The Oak Hill clay was laid down during a later swamp period than that in which the Lower Kittanning coal with its underlying clay was deposited. The intervening strata show that, following the swamp period that produced the coal, the sea again invaded the area and through its action laid down the shales and sandstone, the thickness of which varies from place to place. Following this, swamp-like conditions again existed in restricted areas, during which the clay was formed. From the succession of strata in the interval from the Ferriferous limestone to the Oak Hill clay, it appears that the waters were at all times shallow and that only slight advancements or retreats of the sea were necessary to produce deposition on the one hand of clays and coals, and on the other of shales and sandstones. The repetition of coals and clays in this part of the Allegheny is probably only paralleled in the Mercer interval in the Pottsville, if even there. The sections showing the relation of the Oak Hill clay to other members were given in those covering the Lower Kittanning interval, so they will not be repeated here. They illustrate the variable nature of the interval from the Lower Kittanning coal and also the unsteadiness of the bed as it passes northward and eastward.

Area of the Field and Yield

The area of the Oak Hill clay field above drainage in Jackson County is not large as it is confined principally to western Madison Township, small areas in eastern Jefferson, central and western Bloomfield, and eastern Milton townships. Owing to the uncertainty of the deposits it is hard to get a good estimate of the total area, but probably it will not exceed 15 square miles, yet this is amply sufficient to maintain the present plants for many generations and to justify the establishment of others. The average thickness of the deposit is about 3 feet, of which approximately one-half is flint clay and the remainder plastic clay of good quality. In local areas the bed has a thickness varying from 4 to 5 feet, of which from 2 to 3 feet is flint clay. A deposit 3 feet in thickness, counting 60 per cent available, will yield approximately 6,125 tons per acre, or it will supply a plant making 20,000 brick per day for more than 60 working days. The Oak Hill clay available in Jackson County is thus sufficient for future needs.

Character of the Clay

The Oak Hill clay bed is normally made up of flint clay and plastic clay, the former being found in the lower part of the deposits. There is no definite bedding plane separating them, although the gradation from one kind to the other usually takes place in the space of a few inches. In some localities there are a few inches of ferruginous clay in the lower part of the flint clay bench, while with few exceptions from 3 to 6 inches of the upper part of the plastic clay bench is colored dark with carbon and iron compounds, making this unfit for use. The ratio of flint to plastic clay in the bed is quite variable, for, while the average is about half and half of each, some exposures show but little [illegible] show [illegible] plastic. The flint [illegible] in this respect [illegible] resembling that [illegible] When fresh it varies in color from a light to a dark gray [illegible] somewhat mottled and marked by [illegible] a more glassy appearance. Plant markings are [illegible] usually [illegible] in the [illegible] sharp angular [illegible] have but little plasticity.

The [illegible] which is found in the upper part of the bed is [illegible] than the flint clay, as it contains more [illegible] and ferruginous matter. The iron content [illegible] of the upper part of this bed is often such that the clay is [illegible] for good refractory ware. On weathering or crushing and [illegible] with water it develops good plasticity, but for a bonding clay it is [illegible] inferior to that found below the Lower Kittanning coal.

In the Oak Hill district refractory ware is manufactured on a large scale from the Oak Hill flint and plastic clays. In conjunction with these [illegible] some plastic clay from the Lower Kittanning bed is also used. The process followed in the manufacture of the refractory products depends both on the shape and on the grade of the ware required for the different industries. The best grades of shape and standard wares are made by wet pan grinding, hand molding, hand repressing, and floor drying. The dry pan and pug mill are used to some extent to replace the wet pan. Second grade refractory wares are commonly made by the stiff mud machine process. The clay is ground in a dry pan, tempered in a pug mill, and formed into a column by an auger machine. The column is then cut into the desired sizes by an automatic cutter, and the crude ware pressed by a power press. Another method employs the molding machine which forms the ware from softly tempered mud. Machine-made ware is often dried in tunnel driers, using waste heat from the kilns or exhaust steam from the boilers for maintaining the temperature required. Down-draft kilns are used almost exclusively in the Oak Hill district. Both the circular and rectangular types are found. Coal is the only fuel employed, and most of this is obtained from the clay areas worked. The plants in which the Oak Hill clay is the main raw material used are as follows:

The Aetna Fire Brick Company.
Davis Fire Brick Company.
Ohio Fire Brick Company.
Oak Hill Fire Brick and Coal Company.
The Wm. E. Dee Clay Products Company.

A brief description of each plant is given in the next few pages. The report of the Aetna Fire Brick Company follows:

The Aetna Fire Brick Company was incorporated in 1873, at Oak Hill, Ohio, for the purpose of manufacturing fire brick and fire clay products. The plant was built the same year, but was destroyed by fire about two years later. It was rebuilt the following year.

Up to this time the manufacture of fire brick through this section had not been attempted, the above named company being the first at Oak Hill, and among the first in what is now known as the Southern Ohio district. The rich beds of fire clay, for which this territory has in later years become so widely known, up to that time were untouched for manufacturing purposes. The only brick that were known here were the common red brick made entirely by hand process, and generally on the ground where they were to be used. This type of brick was made chiefly from soil with possibly a little plastic clay to make the bond.

Owing to the excellent quality of clay used, it did not take the products of this first plant long to find a well-established place in the fire brick markets of the country. In a short time the company was unable to supply the demand. As soon as it had been proven that the material of this territory, of which there was such an abundance, would produce fire brick of a superior quality, other companies were organized from time to time, until today there are no less than seven plants at Oak Hill alone, engaged in the manufacture of fire brick and fire clay products. Under normal business conditions, they are all able to run up to their capacity.

The plant of the above mentioned company is located in the northern part of the town, on the B. & O. S. W. railroad, and occupies about three acres of ground. The company also owns a tract of land situated about one-half mile southeast of the plant, just on the outskirts of the town, which is underlaid with flint crown fireclay of the very best quality. The bed which is from 3 to 4 feet in thickness, lies just above the coal; hence coal and clay are mined from the same opening. There is also from 8 to 10 feet of good plastic clay in the same hill. For many years they received almost their entire clay and coal supply from this land, but for the last few years they have been receiving a large part of the clay supply from many small mines and gouges in territory surrounding the plant. This enables them to get a variety of different clays, which are adapted for different kinds of work. This clay, which is delivered at the clay yard by wagons during the summer season, is piled outside to allow it to slack before it is used.

The buildings are all wooden structures. The main building has on the ground floor a 9-foot dry pan, a 9-foot wet or mud pan, molding tables, elevating machinery; on the second floor sand and clay bins, and rotary sand and clay screens. On this floor there is also a large store room for molds and patterns. To the east of the main building, and connected to it, is the main dry house and dry floors. The main floor is 60 by 130 feet, while there is also another floor on the north of this, 32 by 84 feet.

These drying floors are heated by live and exhaust steam, which circulates through pipes placed a few inches below the surface of the floor. During the day, while the machinery is being driven, only the exhaust steam is allowed to pass under the floor. This makes just enough heat to properly temper the brick for pressing. At night the live steam direct from the boilers goes under the floor and furnishes heat enough so that the brick are thoroughly dry by early morning. The brick are then removed from the floor and set in the kilns.

The engine room of the plant, which is joined to the main building on the west side, is 32 by 42 feet. Steam is furnished for the engine, pump, and drying floors, by a 150 horse-power Brownell tubular boiler. The pans, elevators, and other machinery are driven by a 100-horse-power engine. A 5,000 gallon water tank provides storage for the boilers. The water is supplied from a well about 100 feet away by a steam pump, which is housed at the well. A complete new engine room and brick boiler stack have been built within the last three years, and a new 150-horse-power boiler was installed a year ago.

This plant makes only hand-made fire brick, fire tile, and special shapes, and has a capacity of about 12,000 standard brick per day. The clay, after being carefully selected and picked, is ground in the dry pan, and then elevated to the bins on the second floor. It is then let down into the wet pan, where it is thoroughly mixed and tempered. The mud is trucked out to the molding tables to be made into brick. As the brick are molded, they are carried out and laid on the hot floor until they become dry enough to handle, when they are passed through the represses. After being pressed, they are again laid on the floor and allowed to remain until thoroughly dry, when they are ready to be placed in the kiln. This process usually requires from 12 to 15 hours. All regular standard brick are repressed.

We have four rectangular down-draft kilns, which have an average capacity of about 60,000 each Coal is used as fuel in the burning process. Storage room is furnished by a shed 50 by 180 feet, along the east side of which there is a spur track to the B. & O. S W. railroad.

The leading brands of standard pressed brick, in descending order, are, Aetna Steel, Aetna Crown, Aetna, and Aetna O. After over forty years of experience, this company has learned that severe tests are required of a brick to withstand not only the heat resistance, but also the contraction, expansion, and friction, both from flame and wear. From the four leading brands named above, brick can be found suitable for any of the following purposes: blast furnaces, open hearth steel furnaces, locomotive and steamboat fire boxes, smelting furnaces, rotary cement kilns, lime, brick, pottery, and sewer pipe kilns, boiler walls, coke ovens, and for all purposes where a heat and abrasion test is required.

The following report concerning the plants of the Ohio Fire Brick Company and the Davis Fire Brick Company, which are under the same general management, was kindly furnished by the president, Mr. D. D. Davis:

The clays used are the Oak Hill flint and semi-flint, and the Lower Kittanning plastic. The flint clay from the Oak Hill member is about 3 feet in thickness, while the semi-flint clay is from 3 to 4 feet. The deposit of Lower Kittanning plastic clay has a thickness on our property of 9 feet. These clays are mined both by stripping and by drifting, but the main supply is obtained by the latter method. Partial analyses of the clays are about as follows:

	Flint	Plastic
Silica, SiO_2	54.00	59.00
Alumina, Al_2O_3	39.00	31.00

The composition of the semi-flint clay is practically the same as that of the flint clay. The Lower Kittanning plastic clay is very low in iron compounds and is an excellent bonding clay.

The general equipment of the plant of the Ohio Brick Company follows: The buildings for covering the drying floors and for housing the machinery are constructed of wood. The power is furnished by a 150 H. P. engine, the steam for which is generated in a 250 H. P. boiler. The clays are ground and tempered in wet pans, as no machine-made brick are made. The mud is shaped by hand molding into ware, all standard shapes of which are pressed by hand represses when at the proper temperature. All brick are dried on open hot floors, which are heated either by steam or by air direct from coal-fired flues. The ware is burned in five down-draft kilns of 70,000 capacity each. The Lower Kittanning coal mined in conjunction with the clays is used for burning the ware, and for generating the steam for power. The plant is well supplied with storage sheds for protecting the brick from weathering influences. The annual capacity of the plant is 5,000,000 brick, 9-inch equivalents, per year.

The above description applies in a general way also to the plant of the Davis Fire Brick Company, except that the latter has six kilns of 70,000 capacity each, and that it has an annual output of over 6,000,000 brick. The standard brands of brick are Davis Crown, Davis, and Steel. The products manufactured are for blast furnace linings, hot blast stoves, steel mills, coke ovens, open hearth furnaces, and for many other general purposes. Both plants are connected directly by switches to the Baltimore & Ohio Southwestern Railroad, and indirectly to the lines of the Detroit, Toledo & Ironton and the Cincinnati, Hamilton & Dayton Railways.

Mr. D. W. Morgan of the Oak Hill Fire Brick & Coal Company furnished the following brief report concerning that plant:

The Oak Hill Fire Brick and Coal Company, of Oak Hill, Ohio, was established in the year 1873, for the purpose of manufacturing high grade hand-made fire brick. Our wares are made principally from two grades of clay, viz., No. 1 or flint clay, which is deposited in a bed of about 3 feet in thickness, lying directly over the Lower Kittanning coal, and No. 2 or plastic clay, which is deposited in a bed from 6 to 8 feet in thickness, lying just below the previously mentioned coal. The flint clay and coal are mined from the same opening, which is a horizontal drift, while the plastic clay is mined by surface stripping. Our plant is equipped with a 100-H. P. engine, 125-H. P. boiler, two dry pans, one wet pan, and a semi-dry press machine. We have two drying floors, with an area of 32,000 square feet of surface on which the brick are dried by fire flues running the entire length of the floors. Our capacity is 20,000 hand-made brick per day. We have seven down-draft kilns with a capacity of about 60,000 each. The plant is located on the Baltimore and Ohio Southwestern Railroad, which is our only shipping facility. Our storage sheds will hold 1,000,000 standard brick. We manufacture three brands of brick which are designated "O. K. Crown," "A," and "H," respectively. These brick are used for blast furnace linings, hot blast stoves, cupola linings, coke ovens, boiler settings, lime kilns, rotary cement kilns, brick kilns, etc.

A partial analysis of the Oak Hill flint clay follows:

Silica, SiO_2	58.25
Alumina, Al_2O_3	31.02
Water, hydroscopic	10.98
	100.25

A partial analysis of the plastic or Lower Kittanning clay is given below:

Silica, SiO_2	63.12
Alumina, Al_2O_3	26.20

The following report describing the plant and mineral resources of the Wm. E. Dee Clay Products Company, located about one mile south of Oak Hill, was furnished the Survey by the superintendent, Robert E. Miller:

This property consists of nearly 200 acres of mineral land containing two beds of coal, and two deposits of clay which are different in character. One bed is a flint or No. 1 clay, while the other is a plastic or No. 2 clay. The plastic clay is used for the bonding material in the manufacture of hand-made first quality fire brick, while in the production of second grade fire brick, fire proofing, tile, and gas fuel, it is more largely used.

The deposit of flint clay is 3 feet in thickness, and the quantity yielded is 6,000 tons per acre. The bed of plastic clay is from 15 to 20 feet in thickness, and the quantity available is approximately 25,000 tons per acre. These two beds of clay and the 3-foot stratum of Lower Kittanning coal are in juxtaposition, the coal being between the two clay deposits. In addition to the above this property contains an 8-foot deposit of limestone known as the Ferriferous or Hanging Rock bed, and also a thin deposit of iron ore associated with the limestone. There are also 20 feet of shale immediately above the ore, which may be used for the manufacture of paving brick, and rough or smooth faced building brick. All of the above clays, coals, and shales are immediately in the rear of the plant; hence the raw materials are obtained at a low cost.

The plant is equipped with standard machinery, and the ware treated according to the best modern practice. The main building in which the machinery is housed is constructed of wood but is substantially built throughout. All machinery is erected on solid concrete foundations. The line shafting has no connection with the building, as it is supported by independent concrete piers. The main equipment is as follows: one 300-H. P. Bass Corliss engine, two high duty boilers, one 50-H. P. engine of Trotline type, one 20-H. P. engine of same make, two 6-4-6 hot and cold water pumps, one E. M. Freese Independent pug mill, one Freese Mammoth brick and tile machine, one Horton soft mud brick machine, one 9-foot American dry pan, one 8-foot wet pan, one 12-foot blowing fan, one 10-foot exhaust fan, one American revolving automatic cutting machine, two large Eagle represses, one automatic tile cutting machine, 200 steel drying cars, storage sheds, and other things necessary to make it a very complete plant.

This factory has the best designed and constructed drying department in the state of Ohio. It is a three-story fireproof building constructed of concrete and brick. This drier, which is 52 by 160 feet, has 12 tracks for drying the ware which is set on steel cars. Exhaust steam from the engine and waste heat from the kilns are used for drying the green ware. No exhaust steam is allowed to escape to the atmosphere until all of its available heat units have been extracted. After this is done, the water from condensation is utilized for feed water and is returned to the boilers at a temperature of about 212° F.

The burning is done in 6 round down-draft kilns, which have a capacity of about 70,000 each. These kilns are built on solid concrete foundations and have thick walls. Further they are firmly banded with heavy steel.

The following classes and grades of ware are marketed: hollow tile fire proofing, first quality fire brick, second quality fire brick for general purposes, coke oven brick, cupola and foundry ware, blast furnace linings, stove brick, boiler settings, grate tile, gas fuel biscuits and pretzels, rough faced building brick, and paving block. Both lump and ground clays are furnished for many uses.

The market for the entire output of this plant is the Middle West and South. The plant is located on the Baltimore and Ohio Southwestern Railroad. It has its own siding, 1,200 feet in length.

RED KIDNEY ORE

The Red Kidney ore deserves only a passing mention, as the member is seldom present in Jackson County. Its position is only a few feet above the Oak Hill clay. The interval from the ore to the Lower Kittanning coal below varies from 6 to 20 feet, but averages about 10 feet. In local areas in Lawrence and Scioto counties the bed was worked to some extent during the days of the charcoal furnaces, but in Jackson County, from surface indications, it was not so utilized. It is a kidney ore, having a dark red or brown color, where weathered along the outcrop, and from general appearances it is rather rich in iron. Under heavy cover it is a gray carbonate ore, typical of the coal measure deposits. The normal thickness of the bed is 3 or 4 inches, while the maximum is about 8 inches.

MIDDLE KITTANNING COAL

The Middle Kittanning coal is not commercially important in Jackson County, although the bed is generally present in the eastern tier of townships. The great bed found in the counties north has thinned here to a mere fragment, and in its extension southward it expands again in Ohio only along the Symmes Creek Valley in Gallia County, and in the Sheridan region in Lawrence County. In Jackson and Lawrence counties the Middle Kittanning coal rates far below the Lower Kittanning in importance, and the materials associated with the former in no respect compare with the valuable beds of clays and shales occurring with the latter. Although thin, the bed at present yields a small amount of domestic coal, and in the future, as the thicker beds become exhausted, it may supply much needed wants. For this reason the bed will be traced across the county.

Stratigraphy and Extent

The Middle Kittanning or No. 6 coal is the next important coal in the ascending scale above the Lower Kittanning or No. 5. The interval separating the two varies from 20 to 60 feet, but the average is about 39 feet, while that separating the Middle Kittanning coal from the overlying Upper Freeport or No. 7 varies from 60 to 110 feet, but averages about 80 feet. The Middle Kittanning coal is separated from the Lower Freeport or No. 6a coal by shales and sandstones, the average thickness of which is about 37 feet.

The Middle Kittanning coal is found at a few places in the eastern part of Jefferson Township, but, as the bed is near the summits of the hills, the areas are small, and in parts of these the coal is badly weathered. The deposit extends over nearly all of Madison Township, where it has been worked for local use at a few places. The bed is wanting along the preglacial valley in western Bloomfield Township, and it is confined to the eastern half of Milton, but, at the present time, in both of these townships, the bed is not regularly mined, even for domestic use.

Jefferson Township.—Small areas of Middle Kittanning coal are found in Sections 24, 25, 34, and 36, of Jefferson Township. In Section 36, near the old stack of Cambria Furnace, the upper part of a section measured shows the following strata:

	Ft.	In.
Coal, *Middle Kittanning*	1	8
Clay	1	--
Shale, part sandy	14	--
Sandstone, massive, irregular	5	--
Shale	3	--

		Ft.	In.
Clay shale with ore nodules		2	--
Sandstone		3	--
Sandstone, shaly		1	--
Sandstone, massive		9	--
Shale		2	--
Clay, part flinty, *Oak Hill*		1	4
Coal	*Lower Kittanning*	1	2
Clay		1	6
Coal		--	6

Madison Township.—The area of Middle Kittanning coal in Madison Township is large for the bed, although found near the summits of the hills in the western tier of sections dips, so that it is at or near drainage along the eastern boundary. It is present in every section; however the areas in a few sections are very small. Its extent and relations to other beds will now be treated in a more specific way. In Section 6, south, the bed thickens somewhat and is mined for local use on lands of Margaret Hopkins, Evan Reese, and Margaret Evans. The coal in this locality is reported to vary from 1 foot 8 inches to 2 feet in thickness and to be of very good quality, as it is free from partings or slate-bands.

On land of William D. Morgan, Section 31, the Middle Kittanning coal is worked to some extent for house use. A composite section taken there follows:

		Ft.	In.
Coal, *Middle Kittanning*		2	--
Clay shale		1	6
Sandstone, shaly		9	--
Sandstone, with large ferruginous concretions		2	6
Shale, sandy		1	6
Sandstone		8	--
Shale		8	--
Coal stain.			
Clay, dark, plastic		2	--
Sandstone		5	--
Shale		3	6
Clay, *Oak Hill*		2	--
Coal	*Lower Kittanning*	2	6
Clay		--	4
Coal		--	7

In Section 5, south, the Middle Kittanning coal, judging from surface exposures, is about 2 feet in thickness, while in local areas in Section 32 it measures about 3 feet. In this locality the lower bench of coal is from 1 foot 8 inches to 2 feet 2 inches in thickness, while the upper bench, when present, adds about 1 foot to this volume. This coal was formerly mined for railroad shipment by the Comet Coal Company, but the territory is not exhausted. House coal has also been mined at a few places. The character of the deposit in Section

4, south, is shown by the following record made just west of Sardis Church at a mine on the land of Thomas Davis:

	Ft.	In.
Shale, "draw slate"	--	2
Coal, *Middle Kittanning*	1	11
Clay and bone coal, often wanting	--	2

The Middle Kittanning coal is also mined, but by stripping, on the farm of John McCulgan in the same section. He reports the coal to have an average measurement also of about 1 foot 11 inches. In Section 33, domestic coal is mined by drifting on the property of Smith Landrum, where the measurements of the bed practically duplicate those shown above. In Section 3, south, the upper bench of coal is often present, but as a general thing it is an impure cannel coal of little value. The structure of the bed noted at a mine on the farm of J. F. Morgan is recorded below:

		Ft.	In.
Shale, black, tough		2	--
Coal, cannel, impure	*Middle Kittanning*	1	3
Clay		--	2
Coal, good		1	10
Clay		1	--

In places in the mine the lower coal bench has a thickness of 2 feet. In Section 34, the Middle Kittanning coal has been mined for many years to supply local domestic wants. In parts of the area both coal benches are present, and in this case the deposit measures from 3 to 4 feet in thickness. The lower coal bench is usually from 1 to 2 feet in thickness, and is of good quality. The following record obtained at a mine on the farm of W. E. Davis, shows the development where both coal benches are present:

		Ft.	In.
Shale		1	6
Coal	*Middle Kittanning*	2	1
Clay		--	1
Coal		--	10
Clay		1	--

The structure of the deposit shown in the above record was also seen at one mine on the property of John T. Williams, while at another opening near by only the lower coal bench was present, and it has a thickness of 1 foot 5 inches. In sections 35 and 2, south, the deposit is quite steady, but the upper coal bench is seldom present. However, in the latter section on the property of D. W. Williams, the upper coal bench is found. The deposit is mined here for local use. A record taken follows:

		Ft.	In.
Coal, bony	*Middle Kittanning*	--	4
Coal, good		1	4
Clay shale		--	1
Coal, good		1	8
Clay, siliceous		2	--

In this locality the parting between the two coal benches varies in thickness from 1 inch to 2 feet, while the upper coal bench is also subject to variations in thickness. The deposit is below drainage in Section 1, south. Coal has been mined for many years by drifting and also by stripping in Section 36, on the farms of Isaac Alban, J. A. M. Jones, and Jonathan Alban. The lower bench of coal varies from 1 to 2 feet in thickness, but averages about 1 foot 10 inches. The upper bench of the Middle Kittanning coal in this vicinity is seldom present. Near the mouth of a mine on the land of J. A. M. Jones the following record was obtained:

		Ft.	In.
Coal	*Middle Kittanning*	1	11
Clay		1	--
Coal		1	--
Clay		1	--

In this locality the Lower Freeport coal is often separated from the Middle Kittanning bed by a short interval as shown by the following measurements taken along the road in the southeastern corner of the section.

		Ft.	In.
Coal, bony	*Lower Freeport*	--	6
Clay		--	2
Coal, good		1	10
Clay, siliceous		1	--
Shale		9	--
Sandstone, shaly		3	--
Coal, *Middle Kittanning*		1	10

In sections 24 and 25, the Middle Kittanning coal is represented by the lower bench which has a thickness of nearly 2 feet. West of the village of Centerville, on the farm of John O. Williams, the following measurements were obtained in a drift mine which supplies a part of the local fuel needs:

		Ft.	In.
Shale		6	--
Coal, good	*Middle Kittanning*	2	--
Coal, bony		--	2
Clay, siliceous		3	--

The Middle Kittanning coal is usually thin in most of sections 22, 23, and 26, but in local areas it thickens to about 2 feet.

The Middle Kittanning coal has been mined in a small way on the high knobs at several places in Section 21. The bed is reported to be from 1 foot 6 inches to 2 feet in thickness. The coal areas are small in sections 20 and 29, but the bed is quite steady although generally thin. In Section 30, on the land of Samuel Smith, the bed is mined by stripping for local use, and the structure shown is as follows:

	Ft.	In.
Clay shale, dark	--	2
Coal, *Middle Kittanning*	1	9
Clay	1	--

In Section 30, at the mine of the Davis Fire Brick Company, the following measurements were taken:

		Ft.	In.
Coal, *Middle Kittanning*, reported thickness		1	8
Covered		16	--
Sandstone, shaly		6	--
Shale		4	--
Sandstone, shaly		6	--
Shale		2	--
Coal, bony		--	3
Clay shale		--	2
Coal, bony		--	3
Clay, plastic	*Oak Hill*	2	6
Clay, flint		1	8

At the mines of the Ohio Fire Brick Company, in Section 19, the Middle Kittanning coal is reported by the mine foreman, Mr. George Sharp, to reach 3 feet in thickness in local areas. The section measured and reported is as follows:

	Ft.	In.
Coal, *Middle Kittanning*	3	--
Clay	1	--
Shale	20	--
Sandstone	5	--
Ore, kidney	--	3
Clay, *Oak Hill*	3	--

The Middle Kittanning coal is wanting in Section 7, and it is confined to small areas on a few of the high hills in sections 3, 4, 5, 6, 8, 9, 17, and 18. Although the bed is generally thin on these ridges, it is rather steady, but it has not been worked for local use. In sections 10, 15, and 16 the coal is thin, and in places it is replaced by thick sandstones. The best development of the bed observed in sections 11 and 14 is shown in the following record obtained on the land of David T. Davis:

		Ft.	In.
Shale, with sandstone layers		6	--
Coal, cannel, bony	*Middle Kittanning*	--	8
Coal, good		1	8
Coal, bony		--	2
Clay, siliceous		2	--

The Middle Kittanning coal is usually poorly represented in sections 12 and 13, but the Lower Freeport coal in restricted areas has good volume. The following section of the rocks obtained on the farm of Howard Evans shows the interval separating the two beds:

	Ft.	In.
Coal, *Lower Freeport*	1	10
Clay	3	--
Covered	18	--
Sandstone	4	--

	Ft.	In.
Shale	1	6
Coal, *Middle Kittanning*	--	8

No coal of value was found on this horizon in sections 1 and 2.

Bloomfield Township.— The Middle Kittanning coal is rather persistent in most of Bloomfield Township, but the bed seldom has sufficient volume to justify its mining by drifting at present. It seldom exceeds 2 feet in thickness, while it has an average measurement much below this. In some localities the coal is replaced by thick sandstones. Since the deposit is rather unimportant its extent and stratigraphy will be hurriedly treated.

Owing to the rise of the rocks to the west the Middle Kittanning coal passes above the summits of the hills in sections 5, 6, 7, 8, 18, 19, and 30. The areas are small and the coal poorly developed in sections 4, 9, 16, 17, 20, 21, 29, and 31. From conditions observed along its outcrop the Middle Kittanning coal seldom reaches 2 feet in thickness in sections 26, 27, 28, 33, 34, and 35, while more often it is represented by bony shales with thin coal bands. It is present near drainage level along the headwaters of Keeton Run in small areas in sections 24, 25, and 36, where the thickness of the deposit is reported to vary from 1 foot 4 inches to 3 feet, but to be irregular, as the bed is replaced locally by massive sandstones. The coal is thin and unimportant in sections 12, 13, 14, 15, and 24, for it seldom reaches a thickness of 2 feet.

In local areas in the northern part of Bloomfield Township the Middle Kittanning coal is replaced by massive sandstones. This condition is found in sections 1, 2, 3, 10, and 11. The following measurements of the rocks on land of the Superior Colliery Company, in Section 3, illustrate this point:

		Ft.	In.
Sandstone, lower part conglomeratic		65	--
Coal	*Lower Kittanning*	1	5
Clay		--	½
Coal		--	6
Clay		11	--

Milton Township.— In Milton Township the Middle Kittanning coal is confined to the eastern half of the area. The bed is generally thin, and in parts of the region it is replaced by sandstone. The coal is seldom present in sections 26, 27, 28, 33, 34, 35, and 36, for here its place is taken by the massive sandstone found above the Lower Kittanning coal, and measuring often from 60 to 100 feet. Along the road in the central part of Section 14 the coal was exposed and the following measurements taken:

	Ft.	In.
Coal blossom, *Middle Kittanning*	1	--
Shaly sandstone and covered	33	--
Clay, part flint, *Oak Hill*	3	--

The Middle Kittanning with the two Freeports, the Lower Kittanning, and the Clarion coals, were exposed along the roadside that leads from Rich Run to the point southeast in Section 13. The rocks measured from the head of Rich Run to the ridge south in Section 12 are as given below:

		Ft.	In.
Coal blossom, *Upper Freeport*		1	--
Covered		14	--
Sandstone		6	--
Covered		42	--
Shale, sandstone and covered		21	--
Coal blossom, *Middle Kittanning*		1	--
Clay		2	--
Shale and covered		9	--
Sandstone, shaly		7	--
Clay, part flint, *Oak Hill*		3	--
Shale		16	--
Coal	*Lower Kittanning*	2	4
Clay		--	1
Coal		--	3

In Section 11 the Middle Kittanning coal is exposed along the road that leads from Rich Run to the Union School on the ridge north. The bed measured 1 foot 4 inches in thickness, and this probably represents about the normal volume for the area. Along the road in Section 2 the following strata were exposed for measurement:

		Ft.	In.
Coal blossom, *Middle Kittanning*		1	3
Shale, part sandy		15	3
Ore, nodular, *Red Kidney*		--	5
Sandstone, shaly		3	3
Clay, dark	*Oak Hill*	1	4
Clay, light		1	4
Clay shale		2	--
Coal blossom, *Lost Seam*		1	--
Clay shale		2	2
Coal	*Lower Kittanning*	2	1
Clay		--	1
Coal		--	2

Under cover in this locality the Middle Kittanning coal is reported to reach 1 foot 8 inches in thickness, and to be of excellent quality.

The Middle Kittanning coal was well exposed for measurement where stripped for local use along the ridge road north of Lincoln School, in Section 35, north. The upper part of the section obtained here follows:

	Ft.	In.
Coal blossom, *Lower Freeport*	--	6
Covered	17	6
Sandstone, part shaly	29	--
Shale and covered	5	--
Coal, *Middle Kittanning*	1	4

The bed is found near the summit of the main ridge in Section 34, north, but as the cover is shallow the coal is badly weathered and of little value. From surface indications the thickness of the bed in this locality is somewhat above the average.

Economic Value

The average thickness of the Middle Kittanning coal in Jackson County, from the exposures observed, is 1 foot 10 inches, but, as this estimate was obtained largely from surface and shallow mine measurements, the thickness under deep cover may exceed this slightly. However, it is not probable that it will exceed 2 feet. In local areas in the field the bed ranges in thickness from 1 foot 8 inches to 2 feet 6 inches, but in other parts it thins to less than 1 foot, while at other places in northern Bloomfield and southern Milton the deposit is often completely replaced by sandstone. One point in its favor is that, with few exceptions, the member is made up of one coal bench only, consequently the coal yielded is quite free from deleterious clay and shale materials. Some nodules of pyrite or marcasite are present, but this is not sufficient in amount to impair its value for most uses. The coal is rather hard, and usually mines in blocks for the bed, especially under shallow cover, is regularly jointed. The associated clay must be given a low rating, for in quality it is inferior to that of the Lower Kittanning or the Mercer below. It is usually siliceous and ferruginous, thus suitable only for low grades of ceramic ware. The bed is generally thin also; hence it offers but little inducement for working the clay along with the coal. The character of the roof is somewhat variable, but in the main it is satisfactory for mining. The material most generally found above the coal is a siliceous shale having good strength, but in local areas a foot or two of this, lying next to the coal, is replaced by soft clay shale, which soon loosens and falls, owing to the action of percolating waters, while in other places the shale may be completely replaced by sandstone, the massive character of which insures a stable roof.

The total area of Middle Kittanning coal in Jackson County is approximately 35 square miles. After the areas of crop coal, wants, and impure coal are subtracted, the total field in which the deposit has a mean thickness of 1 foot 10 inches is estimated to be in the neighborhood of 15 square miles. Counting 60 per cent available in mining, the deposit will yield about 1,000 tons of fuel per acre.

The coal belonging to the highly volatile bituminous variety, has a good bright luster, is rather firm, and is seldom slaty in character. It is free burning, non-coking, and not especially sooty, while the ash clinkers only under severe heat treatment. No analysis of the coal was obtained, but from general appearances it should compare favorably with the best grades of that found in the counties to the north. The chief value of the Middle Kittanning coal in Jackson County is that the bed may be drawn upon for a small supply of local fuel.

LOWER FREEPORT COAL

The Lower Freeport coal marks the next well recognized horizon above the Middle Kittanning coal, yet in Jackson County it deserves only a passing mention for it adds practically nothing at present to the mineral wealth of the county. The bed is rather steady, especially where shales prevail in the interval, yet the thickness seldom expands sufficiently for mining even for local uses. As the stratum passes southward from Jackson to Lawrence County, the general features of the member are much the same until it approaches the Ohio River, where in one locality the volume increases, and the bed is mined and locally known as the Hatcher coal. Yet in a few restricted areas in Madison Township the bed thickens, and it is mined for a part of the local fuel supply.

Stratigraphy and Extent

The Lower Freeport coal is found usually about midway in the interval from the Middle Kittanning to the Upper Freeport coal, or on the average about 35 or 40 feet from these beds, yet the maximum and minimum variations greatly exceed these figures. Since the member is of but little importance except stratigraphically only a few sections showing its position will be given.

Madison Township.—The Lower Freeport coal in Jackson County is mined only in a desultory way in a few restricted areas in Madison Township. In the vicinity of the village of Centerville, small patches of coal in which the volume reaches 2 feet or more are found. In this locality the Lower Freeport coal lies rather close to the underlying Middle Kittanning member, as the interval separating them is usually from 15 to 25 feet. The following record taken along the road in the southeastern part of Section 36, Madison Township, shows the position of the Lower Freeport coal with regard to the Middle Kittanning bed:

		Ft.	In.
Coal, bony	*Lower Freeport*	--	6
Clay		--	2
Coal, good		1	10
Clay		1	--
Shale		9	--
Sandstone, shaly		3	--
Coal, *Middle Kittanning*		2	--

The Lower Freeport coal has been mined on the above property and also on that of Thomas T. Richard, who reports the bed to be about 4 feet in thickness, but to have small extent. The coal in this locality is overlain by a massive sandstone which often replaces the coal stratum. This coal was mined in a small way in Section 12, on the property of John S. Evans, who reports the structure of the deposit to be as follows:

		Ft.	In.
Coal	*Lower Freeport*	3	--
Coal, cannel		--	5

The areas, however, in which the deposit has good thickness are very local. This member has also been worked in a small way in the vicinity of the Smoky Hollow School in sections 1 and 2. The record obtained on the farm of David J. Edwards is given below:

	Ft.	In.
Coal, *Lower Freeport*	2	--
Clay	1	--

Bloomfield Township.—The Lower Freeport coal was not found in good development in Bloomfield Township, although the bed is usually present in the southern part of the area. In the central part of the township, the coal was seldom observed as it is replaced by thick sandstones. From measurements taken its position in Bloomfield Township is about 35 feet above the Middle Kittanning coal.

Milton Township.—The Lower Freeport coal is rather steady in eastern Milton Township, but the coal is usually too thin to be mined at present except by stripping where the cover is shallow. A few records will be given in order to show the relation of the Lower Freeport coal to other members. The rocks exposed along the road that leads from Buckeye Furnace to the ridge east in Section 25, Milton Township, are shown in the following measurements:

	Ft.	In.
Coal, *Lower Freeport*	1	3
Clay shale	1	9
Sandstone, massive	37	--
Coal blossom, *Middle Kittanning*	2	--

Along the road in the northwestern part of Section 13 the following strata were measured:

	Ft.	In.
Coal blossom, *Lower Freeport*	1	--
Shale and covered	21	--
Sandstone, shaly	10	--
Shale and covered	11	--
Coal blossom, *Middle Kittanning*	1	--

The maximum thickness of Lower Freeport coal observed in Milton Township, was that exposed along the road that leads from Lincoln Furnace to the ridge, in the southwestern part of Section 36, north. The record obtained here follows:

	Ft.	In.
Coal blossom, *Upper Freeport*	1	--
Shale	3	--
Ore	--	4
Shale, gray	6	8

	Ft.	In.
Limestone, nodular	1	--
Shale, soft	3	--
Shale and sandstone	9	--
Coal, good, *Lower Freeport*	1	8

Economic Value

The Lower Freeport coal is usually too thin for important mining, but small amounts may be obtained by stripping along the outcrop or where the cover is shallow. The clay associated with the coal is not of special value, but this and the shales above may be used in the manufacture of ceramic ware. The coal is of good quality,much resembling the Middle Kittanning below in general properties. At present the bed is of more interest for its stratigraphic relations than for its economic value.

UPPER FREEPORT, WATERLOO, OR NO. 7 COAL

The Upper Freeport or No. 7 coal which marks the top of the Allegheny formation, and which is one of the important beds in the counties north, is found well towards the summits of the high hills and ridges along the eastern margin of Jackson County, but the areas of available coal are too small and scattered to form the basis of any considerable mining industry. The characteristic unsteadiness of the bed illustrated in the Waterloo field in Lawrence County, is also indicated by the surface exposures noted in Jackson County, for while in one hill the blossom may be several feet in thickness, in the next it may be only a smut streak. Moreover, in some localities the coal is completely replaced by sandstone. Owing to the decaying influence of shallow cover and to the unsteadiness of the bed the total area in which sound fuel may be obtained is small. The Upper Freeport coal will be traced somewhat carefully across the county for this marks the contact of the Allegheny formation with the Conemaugh above.

Stratigraphy and Extent

The Upper Freeport Coal Horizon is present in Madison, Bloomfield, and Milton townships. But few pockets of coal were found, although the clay is somewhat persistent. The member will be traced in more detail in the next few pages.

Madison Township.—The horizon of the Upper Freeport coal in Madison Township extends along the high knobs and ridges from the Cincinnati, Hamilton & Dayton Railway to the eastern boundary of the township. The coal bed is seldom represented by more than a few inches of coal, while along much of the outcrop the position of the member is marked only by a bed of siliceous clay. However, in one locality northwest of the village of Centerpoint, a small pocket of coal is present, which has excellent volume. The record reported and measured on the land of Evie Jones, in Section 1, south, is given below:

		Ft.	In.
Coal	*Upper Freeport*, reported	--	10
Shale		1	6
Coal		5	--
Covered		3	--
Sandstone		5	--
Shale		5	--
Coal		--	7
Clay		2	--
Shale with limestone nodules		4	--
Covered		50	--
Coal, *Middle Kittanning*		2	--

No coal of value was found on the Upper Freeport horizon elsewhere in Madison Township.

Bloomfield Township.— In Bloomfield Township the horizon of the Upper Freeport coal is confined mainly to areas on the high ridges south of Dickason Run, and east of the Cincinnati, Hamilton & Dayton Railway, and to small areas near the summits of the hills east of Little Raccoon Creek. Coal of value was found only in the latter area, while the extent of the bed here is very local. There are small areas of Upper Freeport coal on the main ridge in the central part of Section 12, and in the southeastern part of Section 1. In the latter there is also an isolated patch near the central part. East of this in Gallia County the Upper Freeport coal is mined in a small way for domestic use. The measurement taken in a mine near the residence of W. F. White, in Section 7, Huntington Township, Gallia County, is here given, as it shows the general character of the bed in this locality:

	Ft.	In.
Coal, *Upper Freeport*, measured near the mouth of a mine	4	2
Covered	4	--
Sandstone, massive, soft	102	--
Covered	5	--
Coal blossom, *Middle Kittanning*	1	--

The member is also due on the high hill in the northwestern part of Section 11.

Milton Township.— In Milton Township the Upper Freeport coal is confined to the two eastern tiers of sections, and in these only the main ridges have sufficient elevation to carry the bed. In sections 36 and 25 small areas are found on the main ridges, but the cover generally is shallow. To the east of this in Vinton County, near the Cooney School, the bed has excellent volume, as is shown by the following section taken at a mine on land of Thomas Sheen, in Section 32, Wilkesville Township, Vinton County:

	Ft.	In.
Coal, *Upper Freeport*	4	7
Clay	1	--

The bed here is reported to have a maximum thickness of 6 feet. The blossom of the Upper Freeport coal is found with only a few feet of cover above it on four knobs on the main ridge in Section 26. In sections 13 and 24 the bed is quite persistent, but generally thin. From Section 13 the Upper Freeport coal extends westward into Section 14, but the horizon soon passes above the hilltops. In Section 12 the cover is quite thick, but from surface indications the coal is generally thin.

Near the Union School, in Section 11, there is a heavy blossom of Upper Freeport coal exposed along the road, but the cover is shallow. The following measurements were made at this place:

	Ft.	In.
Coal blossom, *Upper Freeport*	5	--
Clay	1	--

From Union School the bed extends, with some wants, along the main ridge northward and eastward across sections 2 and 11. A record taken along the road in the northern part of Section 2 is as given below:

	Ft.	In.
Sandstone, soft, *Mahoning*	20	--
Coal blossom, *Upper Freeport*	1	--

In Section 36, north, the Upper Freeport coal is present on the ridges both north and south of Mulga Run, but the bed, from surface indications, is generally thin. It was not found west of this in the northern tier of sections in Milton Township, but a few small areas of coal occur on the main ridge north in Vinton County.

Economic Value

Since the total area is small, the cover generally shallow, and the bed unsteady, the Upper Freeport coal in Jackson County is not of commercial importance. At present it is not mined even for local domestic fuel, as this is more readily obtained from some of the lower deposits. The roof of the coal is generally shale, although in some localities it is the Mahoning sandstone. The mining conditions are usually not the best, for the shale above is somewhat tender, and the Mahoning sandstone, when present, often replaces a part or all of the bed. From surface indications there are only small areas in Jackson County in which the Upper Freeport coal has sufficient thickness to justify mining. Since the overburden is generally shallow, drift mining may be economically practiced where the roof is strong, and stripping where the roof is weathered and broken. The Upper Freeport coal is a good general purpose fuel.

CONEMAUGH FORMATION

The Conemaugh formation in Jackson County contains no members of special importance economically, although the Mahoning sandstone, Mahoning coal, and Mason coal are present in a few localities in eastern Madison, Bloomfield, and Milton townships. In the main the formation is represented by a series of sandstones, gray shales, red clay shales, and bastard limestones. The coal members in the lower part of the Conemaugh formation in this county seldom exceed 1 foot in thickness, while in most of the area they are wanting or very thin.

CHAPTER II

LAWRENCE COUNTY

Introduction

Lawrence County has long been known as the center of the Hanging Rock Iron District, and is one of the important locations of the industry in this State. It first came into prominence in making charcoal iron, and for many years enjoyed the reputation of producing metal of the very highest grades. In this county the industry began in 1826, when Union Furnace was built by Messrs. Sparks, Means, and Fair. From 1826 to 1868 fifteen charcoal furnaces were erected, some of which were in blast for many years, while others with limited supplies of ore and timber were soon abandoned. At present, Center and Olive furnaces, although not in operation, are in a fair state of repair, while the others are represented only by crumbling stacks or cinder dumps. As timber for charcoal became scarce, coke furnaces of which there are now eight modern stacks in the county were built. At present but little native ore is used, as the supply is drawn largely from the rich fields of the Great Lakes.

The charcoal iron industry thus led early to great activity in the mining of ore and limestone which continued for many years, but the present coke furnaces draw little of their supplies from this field. The demand of the furnaces for refractories led to some development of the clay and ganister. At present the region is of interest principally because of its coals, clays, and limestones.

Location and Area

Lawrence County is in the extreme southern part of the State, and consequently it borders on the Ohio River. Gallia County lies to the east and Scioto County to the west, while Gallia, Jackson, and Scioto counties form the northern boundary. The area of Lawrence County, according to the latest work and estimates of the federal government, is 440 square miles.

Topography

RELIEF

This region is part of the old Appalachian Plateau in which the streams have cut deep valleys in the shales and sandstones. This action left the surface very rough and hilly, except the flood plains of the larger streams as the Ohio River, Pine, Storms, and Symmes creeks. The region has been dissected by many small streams whose erosive forces are still very active. Where the strata are mainly sandstones, the valleys are narrow and gorge-like, while where shales predominate they are quite wide and have rather gentle slopes. In the southern part of the county, especially along the Ohio, the strata are mainly sandstones which form many bold cliffs and bare knobs. The village, Hanging Rock, takes its name from one of these cliffs about 250 feet high. Along Storms Creek the sandstones are quite thick, and consequently many cliffs and steep bluffs are present. At Cliffside, and at Vesuvius Furnace, the valley appears walled in with massive sandstone. The hills along the Pine Creek Valley are made up of shales with heavy sandstone layers which jut out to form bold cliffs, or long steep bluffs. In the Symmes Creek Valley, the sandstones are generally near the base of the hills, while the shales above form broad ridges with more gentle slopes. Some of the best farming land in the county is found along these ridges.

The rough broken character of the region has impeded its development, for, while it has been helpful in mining, it has been a great detriment in the marketing of products. The two railroads that cross the county from south to north give very poor service as they have many sharp curves and heavy grades; moreover, they give an outlet only for the western part of the county. Some well constructed macadam roads cross the county, but these have usually many long grades where they cross the divides. The average country road is very rough and hilly.

DRAINAGE

Present Valleys

The Ohio River, which forms the southern boundary of the county, receives directly or indirectly the waters from the entire region. Pine Creek with its small tributaries drains the western part. This stream has a circuitous course as it heads near Moulton in Decatur Township, flows northward to Flowers Station; thence westward into Bloom Township, Scioto County; thence southward to Kelleys Mills; thence northwestward to the Ohio near Wheelersburg. It is a very sluggish stream and meanders freely over its flood plain. It drains most of Elizabeth, Decatur, and Washington townships.

Norman and Osburn runs, both small streams, drain most of Hamilton Township, and flow into the Ohio near Hanging Rock. Little Storms Creek, draining parts of Elizabeth and Upper townships, heads near the tunnel on the Detroit, Toledo & Ironton Railroad, flows south, and empties into Storms Creek north of Ironton. It is a swift stream and has cut its valley in the massive sandstones. Storms Creek, which heads in the western part of Aid Township, flows southward and empties into the Ohio at Ironton. Its valley is the most picturesque in the county, as the stream has carved its way through the massive sandstones that prevail along its entire course. Paradise Park, near Cliffside, with its cliffs, caves, and waterfalls, shows the rugged beauty of the region. Storms Creek drains parts of Elizabeth, Aid, Lawrence, and Upper townships. Ice Creek, with its tributaries, Sugar and Little Ice, drains part of Lawrence, Upper, and Perry townships. The stream heads near Kitts Hill, flows southward and empties into the Ohio at Coalgrove.

Symmes Creek, which enters the county in the northeastern part of Symmes Township, flows south, and empties into the Ohio near Rockwood, is the largest stream in the county. With Indian Guyan it drains the eastern part of the county, except a small tract bordering the Ohio. Symmes, Aid, and Mason townships lie mainly in this basin. This stream also drains parts of Washington, Decatur, Lawrence, Windsor, Union, and Fayette townships. Its largest western tributaries are Big, Sharps, Elkins, Aaron, Johns, and Buffalo creeks. Long Creek is the only eastern tributary of any size. The Symmes Valley is comparatively straight, but the stream itself is very tortuous, and wanders repeatedly across its wide flood plain. The stream enters the county at an elevation of 590 feet, and empties into the Ohio at an elevation of 490, or it has a fall of 100 feet in 36 miles. Indian Guyan Creek enters Lawrence County in Rome Township, flows nearly parallel with the Ohio in its southward course, and empties into the Ohio near Bradrick. It drains parts of Rome, Windsor, and Union townships.

Preglacial Drainage

The present drainage system of the county shows the effect of preglacial rivers. The circuitous course of Pine Creek, the sluggish current of Symmes, the direction of branches of these streams, and the peculiarly bedded clays in high valleys, all can be traced to this source. These old streams have been studied and mapped by W. G. Tight and by others.

Teays and Flatwoods Valleys[1]—In the southern section the most important of these deserted valleys is the well-known Teays Valley. Its relation to the Kanawha River was early recognized, and it has been described by many authors, notably by Prof. I. C. White of Morgantown, W. Va., and by Prof. G. Frederick Wright of Oberlin, Ohio. . . . . . . The other important old drainage way in the southern section is the Flatwoods Valley, back of Ashland, Ky., and opposite Ironton, Ohio; and the Teays and Flatwoods valleys unquestionably form parts of the same system of drainage. . . . . . Further down the Ohio, below Ironton, there are several well-preserved remnants of the floor of the old valley which show from their elevation a gradual descent towards the northwest. These are undoubtedly to be correlated with the Teays and Flatwoods valley floors, as they fall into close accord with the grades of the upper section and carry deposits of similar character. These are found as far north as Wheelersburg.

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[1] Professional Paper No. 13, U. S. G. S., pp. 50 and 57.

> **California Valley**[1]—North of Wheelersburg and near Stockdale, in Scioto County, and extending into Pike and Jackson counties, is the old California Valley, which has been described by the author and Mr. Frank Leverett and correlated with considerable confidence with the Flatwoods and Teays valleys upon the basis of the grade of the old valley floor and the deposits found upon it, which consist of gravel beds of quartz pebbles overlain by silt deposits.
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> **Symmes Creek Valley**—Passing up Symmes Creek from the Ohio opposite Huntington, the valley of the creek, which is less than half a mile wide at the river, becomes a very narrow gorge deeply cut below the high tableland in the vicinity of Marion. North of this gorge, which undoubtedly represents the position of an old col on this stream, and which is called the Marion col, the valley of the stream broadens rapidly to the junction of Sand Fork. The valley of Sand Fork is rather broad, and the stream in its lower course meanders over an extensive swampy plain half a mile or more in width. While the valley of Symmes Creek from the Marion col, as well as the northward continuation of the valley represented by Long Creek, is rather rough and precipitous in character, it is quite comparable in size to that of Sand Fork, and it is very suggestive that the principal erosion of the two valleys was produced by streams of about equal volume, but that Long Creek has been recently enlarged and reversed by the present waters of Symmes Creek.
>
> From the junction of Sand Fork with Symmes Creek a broad, open, flat country extends across the divide to the Raccoon, while further upstream near Evans Mill, the creek runs in a very narrow, deep, precipitous gorge. This gorge undoubtedly represents the position of another eroded col.
>
> From the Evans Mill col northward up Grassy Fork, the valley broadens gradually and its walls become less precipitous, but up Black Fork another deep gorge is encountered but a short distance from the junction of these two streams. The valley of Grassy Fork, as the name indicates, is a broad, open, fertile valley for a number of miles and on the left branch of Grassy Fork opens out into the Cackley swamps east of Camba, while the right branch passes through a narrow gap a short distance above Madison Furnace, and its head waters extend into the flat meadow lands south of Rocky Hill. Beside the gorge on the Black Fork, near its junction with Grassy Fork, there is still another gorge four or five miles further up the stream. These undoubtedly represent the former positions of old cols which have been cut through by the present streams.[2]
>
> **Pine Creek**—The valley of Pine Creek has not been carefully studied by the author, but has been observed at several widely separated points. The lower portion of the valley, which is roughly parallel to the Ohio, has all the characteristics of valleys of the older cycle, as well as the accompanying rejuvenation presented by the deeper trenching of the present creek. The valley, however, narrows rapidly northward upstream, which suggests that within a short distance it might pass into a gorge having the characteristics of a col. This suggestion is strengthened by the fact that at a point 15 or 20 miles further up-stream the creek flows in a rather wide and open valley bordered by low hills, but the exact location of the connection between this upper larger valley and the old drainage line to the west was not determined, yet the possible location of such a connection is suggested. . . . . . These features, taken in connection with the abnormal relation of the present stream to both the old and present drainage, makes it quite evident that the stream is composed of several sections of an older drainage channel, and suggest an interesting field study.[3]

A survey of Pine Creek from its mouth to its source shows that the present stream, with its many laterals, occupies parts of the basins of two tributaries to the old Teays River, and all of that of another.

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[1] Professional Paper No. 13, U. S. G. S., pp. 57-58. [2] *Ibid*, p. 45. [3] *Ibid*, p. 46.

The lower course of the stream from the Ohio River to Kelley's Mills lies in a broad valley, with the bordering hills usually low and well rounded, and with remnants of what evidently represents the floor of the preglacial stream, as they agree in elevation with that of Dogwood Ridge, which evidently marks the undisturbed floor of the old Teays River. Near Kelleys Mills, Pine Creek receives two tributaries, Sperry Fork from the south and Little Pine Creek from the east; the latter seems the natural eastward continuation of the course. At this place Pine Creek makes a sharp turn, and flows northward in a valley more or less constricted, and especially so near Cornwall Station, in Scioto County, where the tortuous course of the stream and the trend of the main ridges indicate the position of a col or divide. Pine Creek, from the Cornwall col south to Kelley's Mills, with Little Pine and Sperry Fork, made up the headwaters of the preglacial stream that flowed northwest from the latter point past Powellsville, and united with the main Teays River south of Wheelersburg. The basin drained by this stream was much the same as that drained at present by Pine Creek south of the Cornwall col, but the latter has deepened the main valleys from 100 to 150 feet, and the laterals have cut their ways farther into the divides, and have more highly dissected the region. The upper course of Pine Creek is formed from parts of two other tributaries to the old Teays River, the abandoned valleys of which are well defined near South Webster, and near Lyra in Scioto County, for their main courses have been but little disturbed, as the present stream appropriated only their headwaters.

One of these streams, which now forms a part of the course of Pine Creek, can be traced west from Lyra to the California Valley. Near Lyra, far out on the flood plain of the Pine Creek Valley, which is very wide, are seen conical hills, that were formed by the present stream cutting across this old water way. Near Vernon school the divide between tributaries to Pine Creek and to Little Scioto has about the same elevation as Dogwood Ridge, which represents the bed of the old Teays River. The divide at Vernon school has an elevation of 700 feet, while that of Dogwood Ridge is 680 feet. From Vernon school the old valley is easily traced westward past the Kettle school and to the Meade school, where it joins the California Valley.

The Cornwall col south of Lyra separated two streams, one of which, south of this divide, now forms the lower course of Pine Creek, and the other of which, north of the divide, flowed west from Lyra, as described above. At Hayward Station, north of Lyra, is another col, although not well defined, which separated the headwaters of this from that of another stream, the old valley floor of which is seen well preserved near South Webster. The three tributaries that formed the headwaters of the small stream that formed near Lyra, and flowed westward, are Howard Run, that part of Pine Creek from the Cornwall col north to Lyra, and that part from the Hayward col south to Lyra. The position of these tributaries is normal and well balanced. The present stream, Pine Creek, thus came down the northern and flowed up the southern tributary, where it cut through into another preglacial stream which now forms its lower course.

The third tributary of the Teays River, which now forms a part of the course of Pine Creek, is well defined, and its old valley readily traced from Moulton, northward, to the mouth of Brushy Fork, thence up this stream and over a divide to Bloom Furnace, thence northwest over a divide at South Webster to Pinkerman, and from this place on to the old California Valley. The head waters of Pine Creek, with the exception of Olive Creek, show a normally developed stream as far as the mouth of Brushy Fork, where it makes a sharp bend and flows through a narrow gorge-like valley for about one mile. Near the mouth of Youngs Branch, just below this gorge, it widens, but is then again constricted to the mouth of Willow Run, below which the valley is generally narrow and the course circuitous.

Between Bloom Furnace and Brushy Fork there is a wide, low divide with an elevation of only 740 feet. The village of South Webster, about four miles northwest of Bloom Furnace, is also situated on a divide about three-fourths of a mile wide and with an elevation of 720 feet. From South Webster northwest towards Pinkerman this old stream is easily traced, and from Pinkerman it is well defined on to the present Little Scioto River. From South Webster it is also readily traced southeast across the divide near Bloom Furnace to Brushy Fork, which it followed to the present stream of Pine Creek. The head waters of this preglacial stream were practically what now make up the head waters of Pine Creek, only these streams have been considerably deepened and rejuvenated, and the courses of some, as Olive Creek, Brushy Fork, Youngs Branch, and Willow Run, greatly modified. Youngs Branch flowed north across what is now Pine Creek and joined the main stream on Brushy Fork about two miles southeast of the Bloom Furnace divide. Willow Run flowed north across Pine Creek and also joined it near the Bloom Furnace divide. The tortuous course of Pine Creek from the mouth of Brushy Fork to the mouth of Hales Creek is due to its cutting its way across these old tributaries of the preglacial stream. Hales Creek from Bloom Station north to Eifort Station was a northern tributary, while that part south to where it joins Pine Creek and the part of this stream thence to the Hayward col was a southern tributary. The upper course of Hales Creek is a part of a tributary to the old Albany River, the broad valley of which is well defined in Jackson County.

Thus the evidence shows that the headwaters of Pine Creek to Brushy Fork are part of the preglacial stream that flowed past South Webster; that at the mouth of Brushy Fork, Pine Creek turned westward cutting across two tributaries of this old stream and then followed down another to the mouth of Hales Creek; that here it turned southward and followed up a southern tributary of this river across the Hayward col and down a northern and up a southern tributary of the old stream seen at Lyra, and that then it crossed the Cornwall col into the stream that now forms its lower course. Pine Creek is thus made up of parts of three of the tributaries to the old Teays River by taking the headwaters of two and the lower course of the third one.

The deposits found in these old valleys are divided into two classes: those made up of interbedded layers of clays and sands with occasional layers of gravel and rock fragments; and those made up entirely of highly stratified fine grained clays. The former were evidently laid down by the direct action of the streams. The coarse material, found mainly near the bed-rock, represents the deposits formed by strong currents on the floor of the river. Above, or occasionally interbedded with these, are found layers of sands and clays, somewhat stratified, which were the alluvial plains of the streams formed largely during flood periods.

The second class of deposits is not of residual or ordinary alluvial origin as they are too fine grained and too free from gravel or sand. Present alluvial deposits carry more or less sand which is mixed with the finer silts or separated in pockets or beds. These beds appear to have been laid down in quiet waters where only the finest of silt or that which remained in suspension for some time would be carried. The evidence tends to show that when the glacier came down from the north these old rivers had their upper courses dammed and filled with drift which produced lake-like conditions in many of these valleys. The drainage was reversed and the streams began to cut new channels during this flood period of long duration. The glacier poured into these new channels more material in the form of gravel, sand, and rock flour, than the streams could carry away, which action further obstructed drainage.

Deposits of gravel and sands would predominate in the valleys directly connected with the glacier, but in the valleys far removed only the finest silt would be carried. These clays appear to represent the silts that remained long in suspension, as only these could drift far out in the quiet waters. Such clays would be free from sand or heavy material. The stratification also indicates quiet water. In texture these clays are very similar to the silt deposited in the still waters far up its branches, during present flood periods of the Ohio.

SURFACE ROCKS

All the surface rocks of this region are of sedimentary origin, and with one exception belong to the Pennsylvanian system. The exception is the alluvium and gravel in the valleys which belong to the Quaternary. The rocks consist of sandstones, shales, conglomerates, clays, coals, limestones, iron ores, and recent alluvium and gravel.

The geology of the region is comparatively simple, except for the remarkable suddenness with which strata disappear or are replaced by others; for illustration, the Lost Seam of coal disappears completely in less than one-half mile, and the shale above the Lower Kittanning coal on Buffalo Creek is replaced by sandstone in less than 100 yards. Along the river hills, the interval from the Upper Mercer ore to the Ferriferous limestone is occupied by massive sandstones, which are replaced by shales near Lawrence Furnace, but the interval is again composed of thick sandstones near Olive Furnace. The heavy sandstone which in a few localities forms the roof for the Ferriferous limestone may be completely replaced in a short distance by clay or shale. The Lower Kittanning coal is thin or wanting near Moulton, but 2 miles north on Nigger Creek it is well developed. The Clarion coal on Painter Creek is normal, but one mile south it is represented by only a few inches of coal which soon thins to a streak. The Ferriferous limestone is very persistent from the northern boundary south to the tunnel on the Detroit, Toledo and Ironton Railroad, south of which it is wanting or is found only in pockets. The Middle Kittanning and Upper Freeport coals which in places have a good thickness are uncertain and may be represented only by their clays. These changes show that generalized conclusions should not be drawn from the minerals found in one locality for they may change radically in a short distance.

The average dip of the rocks in Lawrence County to the east is 25 feet to the mile. It varies however from less than 15 feet to more than 40 feet. The dip of the strata south measured across the greatest width of the county is 9.5 feet to the mile. From these figures the strike of the rocks is found to be 20° 48′ east of north, while the maximum dip at right angles to this is 26.7 feet per mile. The oldest rocks, which lie near the base of the Pottsville formation, are found in the western part of the county. The strata crossed in traveling eastward lie higher and higher in the geological column, and near the eastern border of the county the consolidated rocks found on the hill tops belong to the lower part of the Monongahela formation.

General Table of Surface Rocks in Lawrence County

System.	Series.	Formation.	Member.
Quaternary.	Recent.		Recent alluvium and gravel deposits.
	Pleistocene.		Glacial deposits.
Pennsylvanian		Monongahela.	Pomeroy, Greasy Ridge, or Red Stone coal. Pittsburg sandstone. Pittsburg, or No. 8 coal.

General Table of Surface Rocks in Lawrence County—Concluded

System.	Series.	Formation.	Member.
Pennsylvanian.		Conemaugh.	Connellsville sandstone. Ames limestone. Portersville limestone. Anderson coal. Cambridge limestone. Wilgus coal. Brush Creek limestone. Mason coal. Mahoning coal. Mahoning sandstone.
		Allegheny.	Upper Freeport, Waterloo, or No. 7 coal. Lower Freeport, Hatcher, or No. 6a coal. Yellow Kidney ore. Middle Kittanning, Sheridan, or No. 6 coal. Oak Hill clay. Lost Seam coal. Lower Kittanning, Newcastle, or No. 5 coal. Lower Kittanning clay. Ferriferous, Limestone, or Baird ore. Vanport, Hanging Rock, Gray, or Ferriferous limestone. Clarion, Limestone, or No. 4a coal. Clarion clay. Canary ore. Clarion, or Hecla sandstone. Brookville, or No. 4 coal.
		Pottsville.	Homewood sandstone. Tionesta, or No. 3b coal. Upper Mercer, Franklin, Block, or Big Red Block ore. Upper Mercer limestone. Sand Block ore. Upper Mercer, Webster Block, or No. 3a coal. Lower Mercer, or Little Red Block ore. Lower Mercer limestone. Lower Mercer, or No. 3 coal.

QUATERNARY SYSTEM

RECENT DEPOSITS

The recent deposits on the flood plains of the existing streams belong to the Quaternary System, and they consist of gravels, sands,

and clays, which have been worked over many times by the streams. In the larger valleys these deposits are quite thick, and consist mainly of clays and sand beds, while along the smaller valleys the deposits are much thinner, and consist largely of sand, gravel, and rock fragments.

PLEISTOCENE DEPOSITS

The clay, gravel, and sand beds found in the old preglacial valleys are of Pleistocene age. They occur only in isolated pockets, well above the present streams, and along the terraces that border these old valley floors.

Economic Value

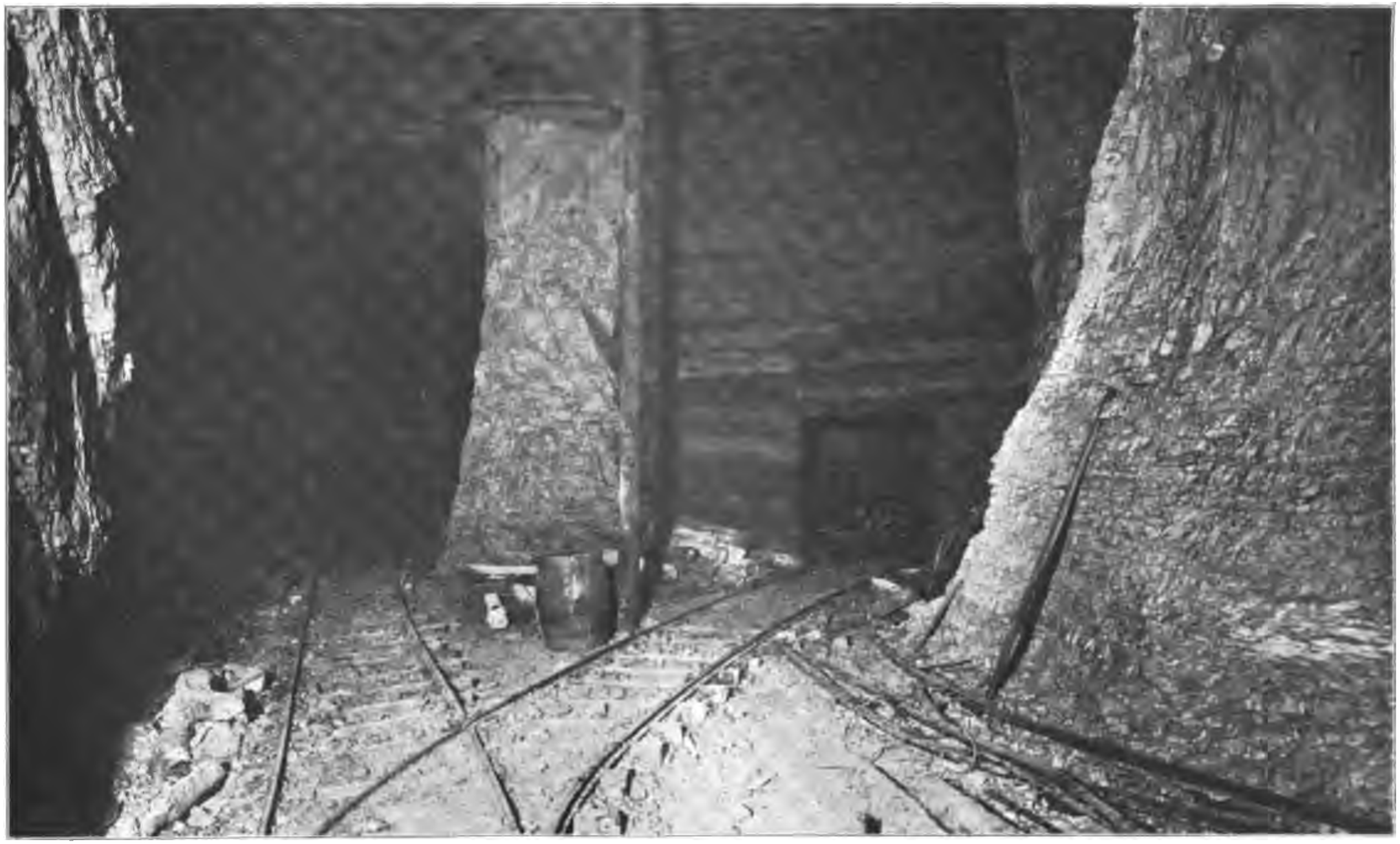
These Quaternary clay beds are often many feet thick, and cover considerable areas. Along the Ohio these tracts are practically coincident with the flood plains, and this is true along the larger tributaries. However, along the smaller streams clays are generally wanting, as their valleys are covered with sands and gravels. The clays may be worked readily into ceramic products. They are best fitted for making red brick and drain tile, but they may be employed also in the manufacture of roofing tile and sewer pipe. The cost of winning and preparing the clay is low. The deposits worked generally lie near the surface, and are exposed by removing the top soil, which usually varies from one to three feet in thickness. The clay is then mined by pick and shovel, pugged to bring it to the right temper, and formed into ware by hand or by machine. Air or artificial heat is used in drying. Common brick are usually burned in the up-draft kilns, but at some plants the down-draft types are used. Drain tile, sewer pipe, and roofing tile are burned in down-draft kilns. The fuel consumption in burning this class of ware is low, as only moderate temperature is necessary. These clays were formerly worked at Ironton for common brick, but the plants have been dismantled.

MISSISSIPPIAN SYSTEM

The Maxville is the highest formation in the Mississippian system. In Kentucky it may be seen well developed in many places, as at Olive hill, Carter County, where it is 90 feet thick; at Limeville, Greenup County, and at places in the Tygerts Valley. In southern Ohio but few exposures are found. A small pocket was noted on the Niner Ridge near Harrison Furnace, Scioto County, and another near the head of the Dever Valley in Hamilton Township, Jackson County. In section 32, Bloom Township, near the Scioto-Lawrence county line, on the Joseph Harper farm, 45 feet of this formation was found by the drill at a depth of 80 feet. Later a shaft was sunk through 25 feet or more of this member. The stone from the shaft is quite dense, light colored, sparingly fossiliferous, and very free from impurities.

In Lawrence County the formation is well under cover, but has been

PLATE VII.



Maxville limestone in the mine of the Ironton Portland Cement Company at Ironton. The deposit in this locality is from 70 to 100 feet in thickness. About 25 feet of the limestone are shown in the picture.

found in two or three places at least in sinking deep wells. At Olive Furnace the drill struck the limestone at 201 feet, and showed it to be 13 feet 6 inches thick. Near Coalgrove the Ironton Portland Cement Company drilled through this formation seven times with a churn drill, and once with a core drill, and in each case the record shows the formation to be well developed. The core drill record, which was kept very accurately shows the deposit to be 70 feet thick, of which 65 feet is limestone. The interval from the top of the well to the Ferriferous limestone was measured by the writer, and found to be 45 feet. The Ironton Portland Cement Company in 1914 completed two shafts, 510 feet in depth, to the Maxville formation, and at present (1916) obtains its entire supply of limestone for cement manufacture from this valuable deposit. All of the 55 feet of this limestone penetrated by the shafts is very free from siliceous material, and is exceptionally low in magnesia and iron oxides. In this mine the deposit is made up of rather regularly bedded layers of limestone, with thin layers of calcareous shales intervening. Vertically the limestone beds are broken every few inches by irregular bedding planes. The limestone is dense, and only sparingly fossiliferous. From the evidence afforded by the eight drill records near the plant of this company, and from those on Little Ice Creek south of the village of Dearing, the area of the deposit in this part of the county will embrace at least 10 square miles, and is probably much more. At Vernon Furnace the log of an oil well, furnished by Harry Moulton, shows limestone at 353 and 464 feet respectively. The upper limestone is probably Maxville, which is a southern continuation of the Harper deposit, reached by shaft in eastern Scioto County. The Maxville limestone was reached by the drill on the William Baker property on Little Ice Creek. The driller stated at the time the drilling was in progress that this limestone was over 85 feet in thickness. Other drill tests made in the county, that went to or below the horizon of this formation, fail to show this member. Thus far the drill tends to show that there are only two deposits of Maxville in Lawrence County, one in the region of the Ironton Portland Cement plant, near Coalgrove, of unknown area, and another beginning near the Harper shaft, and extending southeast to near Vernon Furnace. Future drilling may extend and define these areas, as well as locate new deposits.

W. C. Morse has shown that this limestone is a salt water deposit, that it correlates with the Chester, that it was deposited in regular layers, which were later elevated above water, and then eroded, giving the top an uneven surface, or in places removing the deposits completely. In other words, it was the elevation and erosion of the deposit that produced the patchy character of the Maxville in Lawrence County, and elsewhere in Ohio.[1]

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[1] Geol. Surv. of Ohio, Fourth Ser., Bull 13.

Economic Value

The Maxville limestone in Lawrence County, and also in eastern Scioto, is not surpassed in purity by any other high calcium limestone in this State. Although the deposits are somewhat restricted in extent, the thickness of the bed is such that it insures a supply practically inexhaustible for all future needs in this district. Notwithstanding the fact that the member is reached only by deep shafting, the great thickness of the bed and its freedom from waste material allows the limestone to be mined cheaply when worked in a large way. The deposits are made up of thick layers of limestone, separated by thin layers of calcareous shales, which arrangement allows one or more layers of limestone to be attacked in a regular systematic way, and a uniform product to be yielded in mining. Vertically, the limestone layers, which appear to be solid when viewed in the bed, are broken every few inches by very irregular bedding planes, which aid materially in mining, for when the limestone is loosened by explosives it breaks along these planes into fragments, the main part of which are so small that they may be handled without further reduction. The main headings of the mine of the Ironton Portland Cement Company are driven from 20 to 30 feet in height, or in three distinct layers of the formation. The floor of the mine is over 50 feet below the top of the limestone; hence a good body of this solid material remains to form the roof, which insures safety to the workmen and freedom from water troubles. Although the limestone is quite dense, it is rather brittle; hence it drills easily, in fact, much better than the Ferriferous member of the Allegheny formation. Owing to this brittleness, and to the presence of the closely spaced bedding planes, the cost of mining the material is low.

Description of the plant of the Ironton Portland Cement Company, supplied February 26, 1913, by Mr. A. C. Steece, treasurer and general manager:

> This company was organized in September, 1901, and work was started immediately on the erection of a two-kiln Portland cement plant. We also opened up a coal mine in the fall of the same year, and started entries for our limestone mines so as to have them both ready to furnish fuel and the necessary raw material by the time the mill was ready to be put in operation. This company owns about 800 acres of hill land situated in Upper Township, Lawrence County, Ohio, just east of the corporation line of the City of Ironton.
>
> The Lower Kittanning coal is located about 80 feet above the level of the surrounding country and the Ferriferous limestone, which we formerly used in the manufacture of our product, lies close to 18 feet below the coal. The clay which we use for the silica and alumina of the mixture lies both above and below the limestone.
>
> It was the original intention of this company to use the Lower Kittanning coal in the mill for generating steam and for burning cement in the rotary kilns, which latter requires the coal to be pulverized before use. This we did for several years, but about the year 1905, a natural gas company, whose fields are located in West Virginia, made us a proposition for furnishing us with their fuel, and since then we have been operating entirely with natural gas, both under our boilers and in our kilns.

We completed the erection of our mill in the fall of 1902 and immediately started operations. As our plant was started at the time of the year when there is not much outside work requiring concrete, it was the following spring before we finally got on the market with any quantity of our product, but we are glad to say that we have never at any time had any serious difficulty in making a Portland cement which will compare favorably with any brand made in the United States or elsewhere, and that we have always been able to secure our share of the cement business. We might state that the complaints against our product have been very few and far between, and, in fact, we have never had any serious condemnation of our cement on account of its quality. Our product has gained a reputation for strength all over this section of the country, of which we are proud.

In the last 11 years we have furnished cement for all kinds of important work at a great many points within a radius of 200 miles of Ironton. We have supplied thousands of barrels for the United States government in its work constructing locks and dams in the Ohio, Big Sandy, and Kentucky rivers, and at the present time have two contracts for furnishing cement for locks and dams Nos. 28 and 29, in the Ohio River. A few years ago we furnished several thousand barrels of cement which was used in the completion of Dam No. 37, located at Fernbank, about 10 miles below Cincinnati, this being one of the finest dams yet completed by the government in the Ohio River.

In addition to the government work, we have supplied several hundred thousand barrels to the Norfolk and Western Railway, which was used in building bridges, lining tunnels, etc., throughout the length of their lines. We have likewise furnished cement for any number of smaller jobs, including several private buildings in Columbus, among them being the Masonic Temple, which is just now completed (1913).

We trust you will pardon our digressing in the manner we have, and, to revert back to the mechanical side of our business, will say that after operating our plant with two kilns for about 1 year, we installed a third kiln, these kilns being 6 feet in diameter by 60 feet long, the idea being to take care of our increased business, and likewise to cheapen our product by an increased output. We operated the 3 kilns for 2 years, and then the larger types being installed at different points in the country, we purchased the fourth one, it being 7 feet in diameter and 100 feet long. We were able to get such an increased output from the large kiln that the following year we added 40-foot sections to our 3 60-foot kilns, making them all 100 feet long, with a total capacity of between 1,000 and 1,200 barrels per day.

Of course this increased capacity of kilns meant enlarging our raw grinding department, as well as our finishing department, and likewise increasing the size of our warehouse. By adding to the grinding machinery it became necessary to secure additional power, and we therefore installed extra boilers and added another engine and generator, so that at present our plant produces about 4 times as much cement per day as it did the year we started.

For those not acquainted with the manufacture of Portland cement, we will state that the process consists of grinding limestone with a sufficient quantity of shale or clay, which is necessary to give the required analysis, to a fineness so that approximately 98 per cent will pass through a sieve having 10,000 openings to the square inch. This mixture is then deposited in bins directly above the rear end of the rotary kilns, and from the bins it is spouted uniformly into the kilns, these kilns set at rather a flat angle and revolving at the rate of 1 revolution per minute. The raw mixture gradually works its way toward the front, or discharge end of the kilns. The fuel, either pulverized coal or gas, enters at the front end and meeting the raw stock converts it at a temperature of about 2,400° F. into clinker. This clinker being carried through successive operations of grinding until it is as fine as the raw stock, is finally deposited in bins in our warehouse.

In this operation we first pass the limestone and shale through a No. 7½ gyratory crusher which reduces it to a size so that the largest piece is not over 1¼ inches in diameter, and then through a rotary drier where the entire mixture is thoroughly dehydrated, from there through Jeffrey and Williams' swing hammer mills which grind it to a fineness of 20 mesh, and then into bins from which it is fed uniformly into tube mills, these being cylinders 22 feet long by 5 feet in diameter and about two-thirds filled with flint pebbles. The revolving of these mills reduces the mixture so that 98 per cent passes through a 100-mesh sieve. In the finishing department the clinker first passes through ring rolls, after which it is finished in tube mills similar to those used in the preliminary grinding.

Our entire plant is operated with electricity which is generated by 4 Stirling water tube boilers, totaling 1,500 H.P., 1,200 of which is used continuously, there being 1 boiler idle at all times. These boilers furnish steam for 1 650-H. P. tandem compound engine, direct connected to a 500-K. W. generator, and for 2 350 H. P. simple engines belted to 2 250-K. W. generators.

Of course, in the operation of a plant even of this size, it is necessary to have other departments outside of the mill itself, among them being a machine and forge department where we do most of our repair work, and also a rather complete laboratory, as the quality of Portland cement largely depends on keeping a careful check on the chemical composition, and likewise on the physical tests of the finished product. To do this, we take hourly samples, day and night, including Sundays, of both the raw stock and the finished cement. We test the raw stock to see that it contains the necessary proportion of lime, silica, alumina, and iron. We test the finished product hourly to determine the setting time by means of pats, which we boil for 3 hours, and then leave in steam for 3 hours more, the object being to determine whether or not the cement is sound, as this is supposed to be an accelerated 6 months' test. We try at all times to make cement which will boil, before it goes into our warehouse, and have found that our carefulness in watching these different tests has paid us as it does others, by eliminating complaint as to quality.

We give below analyses of our limestones and clay, together with physical tests made of our product. These results were taken from actual records in our laboratory.

Analysis of the upper beds of Maxville limestone

Silica, SiO_2	1.32
Alumina, Al_2O_3	.23
Ferric oxide, Fe_2O_3	.11
Calcium carbonate, $CaCO_3$	97.14
Magnesium carbonate, $MgCO_3$	.984
Phosphorus, P	.0047
Sulphur, S	trace
Total	99.7887

Analysis of the beds used for cement

Silica, SiO_2	2.50
Alumina, Al_2O_3	.40
Ferric oxide, Fe_2O_3	.10
Calcium carbonate, $CaCO_3$	96.20
Magnesium carbonate, $MgCO_3$	.85
Phosphorus, P	.005
Sulphur, S	trace
Total	100.055

Ferriferous limestone	Sample No. 1	Sample No. 2
Calcium carbonate, $CaCO_3$	96.25	87.14
Alumina, Al_2O_3	.67	1.12
Ferric oxide, Fe_2O_3	1.10	6.30
Silica, SiO_2	.79	1.46
Magnesia, MgO	.93	.87

Lower Kittanning clay	Sample No. 1	Sample No. 2
Alumina, Al_2O_3	29.33	28.41
Silica, SiO_2	54.76	52.84
Ferric oxide, Fe_2O_3	2.20	2.40
Lime, CaO	1.60	2.30
Loss	11.41	11.04

Physical tests of cement

98.2 %	passing 100-mesh sieve
82 %	passing 200-mesh sieve
Initial set	5 hours, 30 minutes
Final set	7 hours, 30 minutes
Boil	O. K.

Tensile strength

7 days,	neat	briquette	585 lbs.
7 “	sand	“	345 “
28 “	neat	“	602 “
28 “	sand	“	400 “
90 “	neat	“	705 “
90 “	sand	“	460 “

While we have been satisfied in the past with the quality of our product, still we realise that the public demands as light colored cement as can be obtained. This demand is growing every day, as the uses found for Portland cement become more varied. For this reason, therefore, as well as that of economy, we are now engaged in sinking two shafts adjacent to our mill to a depth of about 500 feet to obtain a deposit of Maxville limestone which according to test holes put down by us, is about 97 feet thick. According to tests, part of this stone is very high in carbonate of lime, running over 98 per cent. It is likewise very low in iron, and as this ingredient is the cause of color in Portland cement, the resulting product should have a light shade.

PENNSYLVANIAN SYSTEM

All the surface rocks of Lawrence County, except the unconsolidated clays, sands, and gravels along the drainage courses, and laid down during Recent and Pleistocene epochs, belong to the Pennsylvanian system. In the main they consist of sandstones and shales, but they also include clays, coals, iron ores, and limestones. This great division of rocks is divided into four formations, Pottsville, Allegheny, Conemaugh, and Monongahela, all of which are represented in Lawrence County. The Allegheny and Conemaugh formations are exposed in their full thickness. The upper half of the Pottsville rocks is above drainage in the western part of the county, but only a small section of Monongahela strata is present on the high ridges in the eastern part.

POTTSVILLE FORMATION

The lowest Pottsville member of value exposed in the western part of Lawrence County is the Lower Mercer or No. 3 coal. The interval from this bed to the top of the Homewood sandstone, or to the base of the Brookville coal, neither of which is sharply defined, is approximately 180 feet. The Pottsville formation is of less importance at present than it was during the days of the charcoal furnaces, for then its ore beds were mined by benching for miles and miles along their outcrops on the hills. Its coal beds, although usually thin, are increasing somewhat in value, while its clays and shales are coming into prominence for ceramic utilization.

SHARON MEMBERS

Available drill records made in Lawrence County define what is undoubtedly Sharon conglomerate, which exists in a less developed and pebbly state than in Scioto, Pike, and Jackson counties. The Sharon coal appears to be wanting, or at least to be so thin and shaly that it is not a well pronounced bed.

SCIOTOVILLE CLAY

The red mottled clay found in the shaft of the Ironton Portland Cement Company belongs to the Sciotoville member. This impure clay is noted also in drill records, but the high-grade flint clay is not recorded. Owing to the depth of cover only large and pure deposits of this clay would compensate for the cost of shafting.

QUAKERTOWN, WELLSTON, OR NO 2 COAL

A thin bed of coal, which appears to correlate with the Quakertown, is noted in a few drill records. The evidence from this source, however, tends to show that the Quakertown bed, which is a valuable asset to Jackson County, is poorly developed in Lawrence County, or that the productive areas are small and have not as yet been penetrated by the drill.

LOWER MERCER COAL

Stratigraphy and Extent

The Lower Mercer coal is the lowest surface deposit worthy of consideration in Lawrence County. It is found along Pine Creek in the western part of Elizabeth Township, and at a few places along the stream courses in the western part of Hamilton. The Lower Mercer coal usually lies about 45 feet below the Lower Mercer limestone, or only a few feet more than this below the Lower Mercer ore. Its position is only a few feet below the Boggs ore, which is not well represented in Lawrence County.

Hamilton Township.—The Lower Mercer coal passes below drainage near Hanging Rock in Hamilton Township. It is also present along the small stream that leads from the Ohio River to Ohio Furnace. In Section 3, on the farm of J. R. Told, the coal is found in the stream bed near his residence. It has been mined by stripping, to a small extent, and is reported to be 1 foot 6 inches in thickness. The associated black shales, which are always present with this coal in the vicinity of Kelleys Mills, was also observed.

Elizabeth Township.— The Lower Mercer coal in Lawrence County is best represented in the vicinity of Kelleys Mills, on Pine Creek, in the western part of Elizabeth Township, where the bed has been mined in a small way, both by stripping and by drifting, for a part of the fuel supply of the neighborhood. The coal is of good quality, but the bed is somewhat thin and hard to mine. Hard bony shales are directly associated with the coal in this locality, and the general features of the deposit are much the same as they are in parts of Jackson and Scioto counties. A composite section taken north of Kelleys Mills shows the position of the Lower Mercer coal with regard to those of other members higher in the geological column. The measurements follow:

	Ft.	In.
Limestone, *Lower Mercer*	1	--
Shales	18	--
Coal blossom	--	6
Clay shales	1	6
Sandstone	4	--
Covered	4	6
Coal, *Lower Mercer*	1	6

The Lower Mercer coal outcrops near the base of the hills along Pine Creek, but the bed north of Kelleys Mills seldom thickens to over 1 foot. At Union Furnace, on Sperry Fork, this member outcrops near the old furnace stack, where it has been prospected, and is reported to be 1 foot 6 inches in thickness. Along the road south of Kelleys Mills the coal is opened along the roadside, and the deposit here has the following structure:

	Ft.	In.
Ore, *Lower Mercer*	--	4
Covered	21	--
Sandstone	10	--
Shale	--	10
Coal, *Lower Mercer*	1	4

Economic Value

The Lower Mercer coal is a free-burning oily coal with low content of sulphur and ash. It is a good domestic fuel, but the thinness of the deposit and the mining conditions restrict its use. The bony shale below the coal is too hard to cut with the pick, while the overlying shale is cut with difficulty. If the bed had a soft clay below, it could be mined more easily. The deposit is of local interest only. The area of the field is small, as it is confined to a few square miles in the vicinity of Kelleys Mills and Union Furnace.

BOGGS ORE

The Boggs ore, the position of which is only a few feet above the Lower Mercer coal, is poorly defined in Lawrence County. The bed is represented by kidney ores in the shales at a few places along Pine Creek. The position of the Boggs ore is shown in the following section, taken near the Kelleys Mills School, in Elizabeth Township:

		Ft.	In.
Shale		4	--
Ore	*Boggs*	--	2
Coal		--	2
Shale		3	--
Ore, siliceous		1	--
Shale		3	--
Coal, *Lower Mercer*		1	--

The Boggs ore in this locality is siliceous in character, and irregularly bedded in the shales. It was mined but little even for the charcoal furnaces, and is of interest at present only for its stratigraphic features.

LOWER MERCER OR LITTLE RED BLOCK ORE, AND LOWER MERCER LIMESTONE

The Lower Mercer ore was highly esteemed for making iron in the charcoal furnaces on account of the richness of the ore and on account of the quality of the iron produced. The position of the ore is directly above the Lower Mercer limestone, which is much less persistent than the ore. The deposit is invariably thin, averaging from 4 to 6 inches in thickness and having a maximum measurement of 8 or 10 inches. The outcrop of the Lower Mercer members is restricted to the Pine Creek Valley, and to the Ohio River hills west of Hanging Rock. The limestone was noted at a few places in the vicinity of Kelleys Mills, where it is about 1 foot in thickness. These members are found about 55 feet below the Upper Mercer ore, and about 25 feet below the Upper Mercer coal. The Lower Mercer ore was worked but little in Lawrence County during the days of the charcoal furnaces, as the Upper Mercer and Ferriferous ores were much better developed. This ore is of good quality, and in the natural state has from 40 to 50 per cent iron, but the deposits are entirely too thin to be mined at the present time.

Economic Value of the Upper Mercer Shales

The interval from the Lower Mercer coal to the Upper Mercer or No. 3a coal is largely made up of clays and shales, which are well suited for the manufacture of ceramic ware. Below the Lower Mercer limestone 18 feet of shale are found, while above it 25 feet or more are found. The different layers are suited for the manufacture of paving and building brick, and the materials, except the limestone and ore nodules, from the whole interval of 40 feet or more, may be used. It would be a surface mining proposition, where machinery could be used to good advantage, thus making the cost of winning the materials low. The sandy clays and shales are suitable for the manufacture of sewer pipe, but more care would be required in mining the materials for that purpose. The partially weathered shales, as has been demonstrated in practice, make better roofing tile than the unweathered. The available supply of these shales along the Pine Creek Valley in Lawrence County is large, but as yet they have not been developed. The shales, water, and coal are favorable for the successful operation of plants, but the shipping facilities at present are not the best. This is one of the most promising shale horizons for ceramic purposes in Lawrence County.

UPPER MERCER, WEBSTER BLOCK, OR No. 3a COAL AND CLAY

Stratigraphy and Extent

In Lawrence County the Upper Mercer coal is found along the Pine Creek Valley in Elizabeth Township, and along the Ohio Valley west of Hanging Rock in Hamilton. It is also present at a few places in the western parts of Decatur and Washington townships, but in these the bed is usually quite thin. This bed has excellent continuity in Lawrence County, and also in Scioto and Jackson, but it has sufficient volume for mining only in restricted areas. However, the coal is an excellent domestic fuel, and for this reason is mined even where the bed is quite thin.

The stratigraphic position of the Upper Mercer coal is about midway in the interval separating the Lower and Upper Mercer ores, but it is much closer to the Sand Block ore. The interval from the Sand Block ore to the coal varies from 1 foot to 15 feet. The coal lies about 25 feet above the Lower Mercer ore, and approximately 30 feet below the Upper Mercer. These intervals, however, are subject to many variations, owing to the diversity of the conditions under which the beds were laid down.

Hamilton Township.— The Upper Mercer coal in Lawrence County is best developed in the river hills west of Hanging Rock, where it has been worked for local use for years. The bed at its best consists of two coal benches, separated by shale or clay. The lower block is more variable in thickness and quality than the upper one, and often it is wanting, or is represented only by a few inches of black shale. On Norman Run several mines have been worked, but the coal was seen only on the outcrop. Mr. John Simons reports that the Upper Mercer coal on this stream has good thickness. The structure of the bed reported, and the interval to the Upper Mercer ore, is given in the following record:

		Ft.	In.
Ore, *Upper Mercer*		--	8
Covered		28	--
Shale, with parts covered		15	--
Coal	*Upper Mercer*	1	--
Clay		1	--
Coal		1	6
Clay		3	--

Mr. Simons states that the lower bench of coal expands from 1 foot to as much as 3 feet in places in the mines. Just north of Hanging Rock on the Newcastle pike, the coal is opened at the road level, but only the upper block is shown.

In the eastern part of Section 9, on the land of Frank Givens, the Upper Mercer coal is mined in a desultory way, and is reported to be about 2 feet in thickness. West of this, in the same section, on the Joseph Thompson property, the structure of the deposit is shown by the following measurements taken in a drift mine:

		Ft.	In.
Coal	*Upper Mercer*	1	2
Clay		--	11
Coal		--	6
Clay		1	--

At this place the upper bench of coal varies from 1 foot 1 inch to 1 foot 4 inches, while the lower bench expands from 6 to 8 inches. In the hollow north of this, on the land of S. C. Winkler, a number of drift mines were operated for a local fuel supply. John Norris reports that in this vicinity the deposit is from 3 feet to 3 feet 10 inches in thickness, and that there are two benches of coal, each about 1 foot 4 inches thick, and separated by 2 to 5 inches of clay. At this place the coal lies about 27 feet below the Upper Mercer ore. In the western part of Section 9, on the farm of A. C. Bruce, the measurements given below were obtained in a drift mine:

		Ft.	In.
Shale		1	--
Coal	*Upper Mercer*	1	2
Clay		--	4
Coal		--	9
Clay		1	--

At this place the coal is approximately 160 feet below the Ferriferous limestone, and is reported to expand to 4 feet in thickness in some parts of the mine. In the southern part of Section 3, on the property of the Hanging Rock Iron Company, a record which shows the character of the interval from the Upper Mercer coal to the Ferriferous limestone was obtained, and the measurements follow:

	Ft.	In.
Flint and ore, *Ferriferous*	2	--
Clay and covered	27	--
Sandstone, massive	35	--
Sandstone, with parts covered	59	--
Ore, *Upper Mercer*	--	6

		Ft.	In.
Sandstone, shaly		4	--
Covered		8	--
Shale		8	--
Coal	*Upper Mercer*	1	4
Clay			6
Coal		--	8

In the southwestern part of Section 3 the Upper Mercer coal has good volume, and is mined for domestic needs. The following record was obtained on the land of C. M. Lawless:

		Ft.	In.
Shale		2	--
Coal	*Upper Mercer*	1	5
Clay shale		--	7
Coal		1	5
Clay		3	--

In the northeastern part of Section 8, on the farm of George Austin, the Upper Mercer coal has been mined by drifting for many years, and has good volume. A carefully measured section taken at this place is given below:

		Ft.	In.
Shale		16	--
Coal	*Upper Mercer*	1	2
Clay shale, dark		--	8
Coal		1	4

The Upper Mercer coal has also been mined west of this in Section 4, and is reported to be from 2 to 3 feet in thickness.

Elizabeth Township.—From Hamilton Township the Upper Mercer coal extends northward into Elizabeth, where in certain areas it again has fair volume, and furnishes a part of the local fuel supply. Further, the structure of the bed is much the same in this township as it is in Hamilton, and as it is in parts of the fields in Scioto County. Near the forks of the road that leads from Sperry Fork to Little Pine Creek the Upper Mercer and Lower Mercer coals have been prospected. The following measurements were obtained along the roadside:

	Ft.	In.
Coal blossom, *Upper Mercer*	3	--
Covered	10	--
Ore, *Lower Mercer*	--	4
Covered	30	--
Coal blossom, *Lower Mercer*	1	--

Along Fox Hollow, in Elizabeth Township, the Upper Mercer coal has been worked from a few small entries for local use. The two blocks are separated by a thick clay parting as shown below:

		Ft.	In.
Shale		3	--
Coal	*Upper Mercer*	1	--
Clay shale		3	--
Coal		1	--

On the farm of Fred Smith, near Wagoner's Station, on the Detroit, Toledo & Ironton Railroad, several small entries have been worked for local use.

Decatur Township.— The Upper Mercer coal is present on Bear Run and on Pine Creek in the western part of Decatur Township. The extent of the outcrop is small, however, and the coal in places is replaced by massive sandstones. The following record was obtained on Bear Run north of the plant of the Superior Portland Cement Company:

	Ft.	In.
Ore, irregular, *Sand Block*	1	--
Sandstone, shaly	3	--
Shales	7	--
Coal, *Upper Mercer*	1	10
Clay, good, plastic	4	--

Washington Township.—The Upper Mercer coal occurs along Brady Creek in Washington Township, but the bed is seldom over 1 foot in thickness. It lies just below a heavy sandstone, which often replaces it completely.

Economic Value

In Lawrence County the Upper Mercer coal, although somewhat thin, is well worthy of consideration as a mineral asset, on account of the quality of the fuel, and on account of the location of the productive fields which are west of the main body of Allegheny coals. Further, the underlying clay has a value from a ceramic standpoint, as it is usually of good quality. The coal from this bed is a high volatile, free-burning fuel, and, with the exception of the Quakertown, it is the best of the Pottsville coals for domestic use. It has a low content of ash and sulphur, and like the Quakertown it produces but little soot during oxidation. The coal benches are usually broken by vertical joints into blocks; hence it is often called block coal. Owing to this blocky structure the coal mines in large lumps, with but little loss in fine material. As a general thing the coal is overlaid by a tough shale, which forms an excellent roof. In a few places, however, the roof material is sandstone, which is also safe, as it is massively developed and free from shaly partings. In a few localities only a foot or two of shale intervenes between the coal and sandstone, which condition is somewhat dangerous to the life of the miner. The floor of the bed is, with few exceptions, a plastic but often siliceous clay, while the parting between the two coal benches is of the same character. The cutting is done in these clays. On the whole the mining conditions are satisfactory for a thin bed. In estimating the value of these thin Pottsville coal beds the underlying clay should also be taken into consideration, especially if the clays have ceramic qualities, and if the conditions are favorable for their utilization. While the Upper Mercer coal is generally thin, a good plastic fire clay is usually found below it. Where both coal and clay may be used to advantage the deposits become important. The section on Bear Run shows:

	Ft.	In.
Coal	1	10
Clay, good, plastic	4	--

The specific gravity of coal is 1.3, and that of clay 2.49. If 60 per cent of the total coal and clay can be mined, the coal per acre would yield 1,947 tons, and clay 8,135 tons. Three and one-half tons of clay make a thousand standard building brick, so 8,135 tons would make 2,324,000. Under favorable conditions six-tenths of a ton of coal is sufficient fuel for burning a thousand brick; hence the fuel required would be 2,324 × .6 = 1,394 tons. This leaves 553 tons for steaming purposes which is about the amount necessary. Therefore, a 1 foot 10 inch bed of coal will furnish, under economical conditions, the total fuel requirement to manufacture a 4-foot deposit of clay into ware. At $8.00 per thousand at the plant, the value of the product per acre would be $18,592.

These plastic clays are well suited for the manufacture of buff and iron mottled building brick, or of sewer pipe. Where the clay and coal are both worked the height is sufficient for ease in mining. The clay is mined from below the coal, which is then loosened by wedging or shooting. Under these conditions the cost of mining would be from 30 to 50 cents per ton for the clay, and from 50 to 70 cents per ton for the coal.

SAND BLOCK ORE

The Sand Block ore, which outcrops along the western edge of Lawrence County, lies between the Upper Mercer coal and the Upper Mercer ore. In some places the deposit is only a foot or two above the coal, but usually it is from 10 to 15 feet. The ore, which varies from 4 to 12 inches in thickness, is quite siliceous, and has been worked at only a few places in Lawrence County, but more generally in Scioto. The deposit has but little value at present. Sections showing the position of the Sand Block ore are given under Lower Mercer ore, and under Upper Mercer coal; hence they will not be repeated here.

UPPER MERCER ORE

The Upper Mercer deposit is known as the Block or Franklin ore of Lawrence County, and as the Big Red Block ore of Scioto County. For years the charcoal furnaces in the western part of Lawrence County drew a considerable part of their ore supply from this member. Next to the Ferriferous ore, it is the most important ore bed in this county, although the member is best developed in Scioto County near Ohio Furnace. The Hanging Rock Iron Company for many years drew a small supply of ore from this field for its coke furnaces, but the company abandoned the mines in 1913. The ore, which has not been worked to any extent in late years in Lawrence County, is generally siliceous, but in some grades of iron it may be used to good advantage in place of the Lake ores used at present.

The Upper Mercer ore was exposed only at a few places, but the old benches from which it was taken can be followed for miles, as this bed was largely worked by the charcoal furnaces along the Pine Creek Valley, and along the Ohio River. But little has been mined for years except near Ohio Furnace in Scioto County. The ore is above drainage in Hamilton, and in the western parts of Upper, Elizabeth, Decatur, and Washington townships. It goes under cover on Storms Creek near the Kelley School, on Little Storms Creek near Lagrange Furnace, on Little Pine Creek near Lawrence Furnace, and on Pine Creek near the mouth of Youngs Branch. The maximum thickness of the ore is 2 feet, but in many places it is thin or wanting, as the ore has been replaced by sandstones. This ore lies on the horizon of the Upper Mercer limestone, and when the limestone is present the ore is found directly above it. In Lawrence County the limestone is wanting, but the ore is quite persistent. Many of the sections with the measurement of the ore are taken from previous reports of the Survey. The interval from the Upper Mercer ore to the Ferriferous ore varies from 100 to 130 feet, but the usual measurement is from 110 to 120 feet.

Stratigraphy and Extent

Upper Township.—The Upper Mercer or Block ore is present along the lower parts of the valleys of Storms and Little Storms creeks. It was mined rather extensively for the charcoal furnaces, but is not used at present. Just north of Ironton, in Kronnacker's spring house, the ore has the following structure:

		Ft.	In.
Sandstone, with finger coal at base		5	--
Disconformity.			
Shale, with ore nodules		1	10
Ore, kidney, good	*Upper Mercer*	--	6
Ore, siliceous		1	6
Clay, soft, plastic		1	--

Along the lower course of Storms Creek this ore was worked considerably by stripping, and is reported to be from a few inches to 2 feet in thickness. The quality of the ore is stated to be the best when the bed is thin. On Storms Creek it passes under cover just below the Kelley School, and on Little Storms Creek it disappears from view near Lagrange Furnace.

Hamilton Township.—The outcrop of the Upper Mercer ore is readily traced on Osburn Run by the old benches which extend along the hillsides. Near the school, where the member was exposed along the bank of the stream, the ore measured 10 inches, and had clay for the covering stratum. West of this stream, on Norman Run, the ore, judging from the depth to which it was mined by stripping, is also well developed. In this locality the ore is reported to be from 6 inches to 1 foot 6 inches in thickness. The bed is very persistent also west of this stream, where the following record was measured in Section 3, on the land of the Hanging Rock Iron Company:

		Ft.	In.
Ore, *Upper Mercer*		--	6
Sandstone, shaly		4	--
Covered		8	--
Shale		8	--
Coal	*Upper Mercer*	1	4
Clay		--	6
Coal		--	8

Elizabeth Township.—The Upper Mercer ore was worked along the courses of the streams in the western part of Elizabeth Township where the bed has good continuity and volume. This ore constituted a part of the regular burden for the charcoal furnaces Center, Lawrence, Pine Grove, and Union. In this township, from measurements and reports, the ore varies in thickness from 4 inches to 2 feet. The mean thickness however is from 5 to 10 inches. On Little Pine Creek west of Lawrence Furnace the ore is reported by Thomas Coyer to vary from a few inches to 2 feet in thickness. Generally the roof is shale, but in some places it is a massive sandstone. In some of the workings he reports the ore as follows:

Red ore, upper block	6 to 10 inches
Gray ore, lower block	8 to 12 inches

Near the pond at Lawrence Furnace the ore was exposed on the outcrop, and measured 6 inches.

North of Kelleys Mills along Pine Creek the Upper Mercer ore has been mined in many places. On the Fred Smith farm the ore measured 6 inches in thickness, while north of this, on Cooney Branch, it was 8 inches thick where exposed along the banks of the stream. In both places the ore was siliceous in character.

Decatur Township.— The Upper Mercer ore is found along Bear Run and along Pine Creek, in the western part of Decatur Township. Here the bed is only moderately steady, as it is often replaced by thick sandstones. These regions contributed but little ore to the old charcoal furnaces that were built and operated in the district, as their supply was drawn largely from the far richer and better developed Ferriferous ore. In this township the member lies from 95 to 120 feet below the Ferriferous limestone, and it has an average thickness not to exceed 6 inches.

Washington Township.—The charcoal furnaces in Washington Township obtained a small quantity of ore from the Upper Mercer bed, which is present only along the stream courses in the western part of the township. The ore is usually thin, and the member unsteady.

The flux stone used is as follows:

Ferric oxide, Fe_2O_3	.52
Silica, SiO_2	2.30
Alumina, Al_2O_3	.70
Phosphorus, P	.015
Calcium carbonate, $CaCO_3$	90.16
Magnesium, $MgCO_3$	5.90
Water, H_2O	.12
Combined water, H_2O	.25

In these comparisons 2 per cent silicon and 4 per cent total carbon are figured to the iron. In ordinary practice about one-half the manganese found in the burden goes to the iron, while the remainder is carried out in the slag and this condition is used in the comparisons.

The iron produced is made up of the following:

Total iron in burden of ore, stone and coke.	
Total phosphorus in burden of ore, stone and coke.	
One-half manganese in burden of ore, stone and coke.	
The three above items equal	94 per cent of the total pig.
Silicon	2 per cent.
Carbon	4 per cent.
Pig iron produced	100 per cent.

In the slag the ratio of acids to bases is held at 1 : 1, that is,

$$\left\{\begin{array}{l} CaO \\ MgO,\text{ when low} \\ MnO,\text{ when low} \end{array}\right\} : \left\{\begin{array}{l} SiO_2 \\ Al_2O_3 \end{array}\right\} :: 1 : 1$$

The heat units required for the reduction of the ore, breaking up of stone, and slagging of the gangue of ore and coke, together with the heat lost in the process, and also heat produced by the burning of the coke, are based on figures obtained from Richard's calculations. The ratio by volume of $\frac{CO}{CO_2}$ 1.8 is held, as this denotes economy of fuel. This ratio is easily reached in practice.

Col. H. A. Marting of Ironton reports as follows:

> The freight rate on Lake Ores from the docks at Toledo or Cleveland to Ironton is 90 cents per ton of 2,240 lbs. The average price of Pocahontas coke delivered at Ironton would be approximately $2.85 per ton of 2,000 lbs. This is taking the average price over a period of about ten years.
>
> The general over and above cost including the labor, taxes, insurance, office expenses, maintenance of property, and cost of marketing, would be somewhere in the neighborhood of $1.00 per ton of ore smelted. This is on the basis of smelting approximately 540 tons of ore per day. The cost of native limestone per ton of 2,240 lbs. is from 80 to 85 cents, delivered at Ironton.[1]

Mr. W. M. Jefferys of the Hanging Rock Iron Company reports as follows:

> Limestone, cost per gross ton at furnace, 85 cents. Average cost of net tons of coke at furnace, $3.05. Freight on Lake ore, 90 cents per gross ton. Over and above

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[1] Personal letter, dated Feb. 26, 1913.

of the Upper Mercer o **TABLE I**

basis of smelting 540 gross tons ls of ore. Basis of smelting 540 gross tons per day[a].
and Empire ores used for comparison.

Coke required per 2268 pounds iron produced.	Gases in cubic feet at 200°C per pound coke used.	Air in cubic feet at 20°C per pound coke used.	Water.	Cost of coke for smelting at $3.05 per ton 2000 pounds.	Total cost of smelting one ton 2240 pounds ore.	Cost per ton 2268 pounds iron produced.	Comparative value of ores, using cost of Hanna No. 1 as basis on pig iron produced in smelting.	Comparative value of ores, using cost of Empire as basis on pig iron produced in smelting.
2,584	131	61	1.4	$1.6414	$5.2087	$12.50	$2.06	$2.91
3,080	146	65	2.1	1.5167	4.9782	15.42	1.10	1.76
2,864	140	64	3.1	1.7275	6.5322	16.51	1.54	2.35
2,754	140	64	3.0	1.7603	6.1807	14.75	1.79	2.65
1,777	135	56	13.0	1.4279	6.6849	12.69	4.04	5.12
2,295	128	59	1.4	1.6059	5.0360	10.98	2.76	3.71

The ore used as stan
per ton. The ores us

cost per ton of pig iron, including all labor and repair costs, taxes, insurance, etc., would be $1.0936; cost of native ore per gross ton delivered at furnace would be $1.92 for the "Limestone" ore, and $1.98 for the Block ore.[1]

Oglebay, Norton & Co. quote Empire ore for season of 1912 at lower lake ports at $1.75 per ton.

Pickands, Mather & Co. quote Vivian for season of 1913 at lower lake ports at $2.15 per ton.

In these comparisons the following figures are used:

Over and above costs	$1.00 and $1.0936 per ton of ore smelted.
Block ore per gross ton	1.98
Empire ore per gross ton	1.75
Vivian ore per gross ton	2.15
Coke per net ton	2.85 and $3.05
Stone per gross ton	.85
Freight on Lake ore per gross ton	.90

The common practice of the charcoal furnace operators where carbonate ores were used was first to calcine them, which action was an advantage, as the ores then reduced more readily in the short stacks. This same practice was also followed where the ore was used in the large coke furnaces. Mr. W. M. Jefferys reports, "We have not attempted to use this ore in the natural state. It has always been calcined, but we are of the opinion that it could be used in the natural state by crushing."

In the breaking up and in the reduction of the ores the following heat units are required when the grams of the substances used are equal to the molecular weights.

$$\begin{array}{lll} 4FeCO_3+(4\times 24{,}900 \text{ cal.} & = 99{,}600 \text{ cal.}) & = 4FeO+4CO_2 \\ 4FeO \quad +(4\times 65{,}700 \text{ cal.} & = \underline{262{,}800} \text{ cal.}) & = 2Fe_2 +2O_2 \\ & \quad 362{,}400 \text{ cal.} & \end{array}$$

Thus the total heat required to break up $4FeCO_3$, and then reduce the 4FeO to $2Fe_2$ is 362,400 calories, or the calories per unit of iron are 1,618.

Where the carbonate is first roasted to the ferric oxide and then reduced, the heat required is as follows:

$$\begin{array}{lll} 4FeCO_3+(4\times 24{,}900 \text{ cal.} & = 99{,}600 \text{ cal.}) & = 4FeO\times 4CO_2 \\ 4FeO+O_2 & & = 2Fe_2O_3+(2\times 64{,}200 \text{ cal.} = 128{,}400 \text{ cal.}) \\ 2Fe_2O_3+(2\times 195{,}600 \text{ cal.} & = \underline{391{,}200} \text{ cal.}) & = 2Fe_2+3O_2 \\ \text{Heat of reduction used} & = 490{,}800 \text{ calories.} & \\ \text{Heat of oxidation given} & = \underline{128{,}400} \text{ calories.} & \\ \text{Heat required} & = 362{,}400 \text{ calories.} & \end{array}$$

It is seen from these calculations that the heat energy required is exactly the same. The results are different when the heat required to smelt the raw carbonate is compared with that required to smelt the calcined ore, as shown below:

$4FeCO_3$ requires 362,400 calories for its complete reduction, while $2Fe_2O_3$ requires 391,200 calories for its complete reduction, or, 28,800 calories more are required in the second case to produce $2Fe_2$ than in the first case. This is an excess of 129 calories per unit of iron, or 129 calories more are required to reduce one unit of iron from the oxide than from the carbonate, so that from this point of view there is no special economy in roasting the ore.

When charged into the blast furnace and reduced, other effects must be considered also. The CO_2 produced carries out heat while the O_2 given up by the iron oxide combines with the CO gas to form CO_2 with evolution of heat. The temperature at which the gases leave the furnace is ordinarily 200° C. The specific heat of CO_2 at this temperature is .414. When the carbonate ore is charged into the furnace, the heat items are as follows:

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[1] Personal letter, dated Feb. 27, 1913.

Heat used to break up $4FeCO_3$ = 362,400 calories
Heat carried out by $4CO_2$ (176× 200×.414) = 14,753 calories
Heat given by oxidation $4CO+2O_2$ = $4CO_2$+(4×12×5,670)=272,160 calories.
Heat carried out by $4CO_2$ (176×200×.414) = 14,753 calories
Heat used = 391,906 calories
Heat given = 272,160 calories
Heat required = 119,746 calories

This 119,746 calories must be furnished by the oxidation of C to CO by air.

1 unit C burned to CO gives 2,430 calories.

The gases produced carry out the following at 200° C.

$\frac{7}{3}$ units CO = $\frac{7}{3}$ × 200 × .3084 = 144 calories
$\frac{307.6}{69.3}$ units N_2 = $\frac{307.6}{69.3}$ × 200 × .2448 = 217 calories
Total 361 calories

Radiation losses are not considered in the above.

2430 calories — 361 calories = 2,069 calories available heat

$$\frac{119,746}{2,069} = 58 \text{ units carbon}$$

So total carbon units required are 58+48 = 106, which must be supplied by the coke. The units of iron reduced by 106 units of carbon are 224, or the carbon per unit iron is .473.

When the calcined ore is charged the items are as follows:

Heat units required to break up $2Fe_2O_3$ = 391,200 calories
Heat given by oxidation $6CO+3O_2$ = $6CO_2$ (6×12×5,670) = 408,240 calories.
Heat carried out by $6CO_2$ (264×200×.414) = 21,859 calories
Heat used = 413,059 calories
Heat given = 408,240 calories
Heat required = 4,819 calories

The 4,819 calories yet required must be supplied by the oxidation of C to CO by air, which gives 2,069 calories per unit C. The equation follows:

$$\frac{4,819}{2,069} = 2+ \text{ units C}$$

Total units carbon required are 72+2 = 74, so in this case 224 units iron are reduced by 74 units carbon or carbon per unit iron is .330. The difference in carbon per unit between using the raw and calcined ore is .473—.330 = .143, or 14.3 per cent of the weight of the iron. This saving of carbon will justify the calcining of the carbonates especially where it can be done with cheap fuel.

The calcining of ore is also expensive for several reasons. The ore is handled once or twice more than if used raw, and while low grade fuels are generally used, these must be given a value. Considerable ore is lost in dust that results from the extra handling and calcination. Some of the ash from the fuel used is mixed with the calcined ore, thus increasing the gangue to be fluxed in the furnace.

There are also several points against using the raw carbonate. In a normal working furnace the Fe_2O_3 is reduced to spongy metallic iron near the top. The $FeCO_3$ is broken up and reduced several feet lower or close to where the slag zone begins. The carbonates are dense; hence their impervious character retards greatly the reducing action of the gases, as the CO_2 must first be expelled and then the FeO reduced. If the ore is added in large pieces before this breaking up and reduction is complete, it may be carried far down into the slag zone, which generally causes trouble. If the ore is crushed to small pieces, the breaking up and reduction will take place in the proper zone. Magnetites for years were held in disfavor, as the furnace managers were trying to use them in too large pieces, but at present they are crushed and work very satisfactorily. The carbonates, if used raw, should also be prepared by crushing before use.

In a measure the capacity of a furnace is limited; that is, the amount of stock which can be charged per day. The carbonate and oxide ores compare in weight as follows:

$2FeCO_3 = 232$; or ore per unit iron $= 2.07$
$Fe_2O_3 = 160$; or ore per unit iron $= 1.43$

From the above it follows that, if carbonates alone were charged, the tonnage of iron produced from the furnace would be much less than where oxides alone are charged. In the table where the two are compared in this way, it shows that 3,080 lbs. of coke are required to smelt 2,268 lbs. of iron from the carbonate and only 2,584 lbs. of coke for the iron from the oxides. This difference is due to the capacity of the furnace and to the low yield of iron when the carbonate is used, as in both cases 540 tons ore were charged.

These siliceous carbonate ores give a low yield of metal, but they may be utilized to good advantage to bring the silica in the burden up to the quantity required. Their value is considerably increased if the ore is calcined before use. On the whole, the Upper Mercer ore of Lawrence County is equally as valuable as the siliceous Lake ores. It belongs to the class of ores adapted for the smelting of foundry iron. The member is well worthy of consideration as a mineral asset of the county and is of interest also in connection with the early history of iron making in the Hanging Rock Iron Region.

TIONESTA OR No. 3b COAL AND CLAY, AND ASSOCIATED SHALES

Stratigraphy and Extent

The Tionesta coal is very persistent in the northern part of Lawrence County, and has been worked in a small way for many years. It has been mined on Darby, Buckhorn, and Olive creeks, and on Brushy Fork in Elizabeth and Decatur townships, but the bed is best developed on Brady Creek in Washington Township. While this coal is found in the southern part of the county, it has not been worked south of Little Pine Creek in Elizabeth Township. The thickness of the member, where best developed, is only from 2 to 3 feet, but the quality of the coal is excellent for domestic use.

The Tionesta coal is found about midway in the interval between the Upper Mercer ore and the Brookville coal, which is poorly represented in Lawrence County. The Tionesta bed lies about 32 feet above the Upper Mercer ore, and about 63 feet below the Ferriferous limestone. It is often called the 60-foot coal, owing to the fact that it occurs about 60 feet below the limestone, which is the most important bed for reference in the region. The clay below the Tionesta coal usually has good volume, but is somewhat siliceous in character. The associated shales have ceramic qualities, and in many places have good thickness. These beds will also be considered under the above heading. The Tionesta coal extends from the Ohio River northward into Jackson County. It is best developed in Elizabeth, Decatur, and Washington townships, although it is present in Hamilton and Upper.

Upper Township.—The Tionesta coal is poorly represented in Upper Township, as the bed in much of the area is replaced by thick sandstones, or is marked by thin deposits of carbonaceous shales, with impure coal bands. No Tionesta coal of value was found in this township.

Hamilton Township.—Massive sandstones replace the Tionesta coal in most of Hamilton Township also. In the western part of the area about 1 foot of this coal was observed at a few places on the main ridges.

Elizabeth Township.—The Tionesta coal is better developed in Elizabeth Township than in either Upper or Hamilton. However, the areas in which the bed has sufficient thickness to be mined by drifting, even in a small way, are not large. It has the best volume along Little Pine Creek, where house coal has been mined at a few places. The following section, taken at Lawrence Furnace, shows the position of the Tionesta coal with reference to other well known beds:

	Ft.	In.
Limestone, *Ferriferous*	7	--
Coal blossom, *Clarion*	--	2
Clay, good, plastic	8	--
Shale and shaly sandstone	17	--
Coal blossom, *Brookville*	--	6
Shale	3	--
Coal blossom	--	2
Clay shale	3	--
Sandstone	1	--
Shale	14	--
Shaly sandstone	8	--
Shale	9	--
Coal, *Tionesta, No. 3b*	1	--
Clay	3	6

The Tionesta coal, lying about 64 feet below the Ferriferous limestone, is quite persistent, and farther north it thickens considerably. The interval from this bed to the limestone in this region is from 60 to 70 feet. Near Empire Furnace, in Scioto County, the local coal supply is drawn largely from this bed. On Cooney Branch, near the Lawrence-Scioto county line, the section is as follows:

		Ft.	In.
Shale, dark, tough		12	--
Coal	*Tionesta*	--	9
Bone coal		--	1
Coal		1	--
Clay		--	6
Coal		--	6
Clay shale		2	--

On the lands of Etna Furnace, in sections 16 and 21, the Tionesta coal occurs 62 feet below the limestone, and is 1 foot 5 inches thick.[1] At the head of Darby Creek, north of Lawrence Furnace, the coal has been mined in a small way. Its position is 66 feet below the Ferriferous limestone, and its structure is shown in the following section:

		Ft.	In.
Shale, dark colored		6	--
Coal	*Tionesta*	1	--
Clay		--	6
Coal		1	--

South of Center Furnace, in Elizabeth Township, the Tionesta coal has the following thickness and structure:

		Ft.	In.
Shale		6	--
Coal, good	*Tionesta*	--	11
Clay		--	5
Coal, good		--	6
Coal, bony		--	11

Decatur Township.—In its extension northward from Elizabeth Township into Decatur the Tionesta coal thickens somewhat, but it has sufficient volume for drift mining only in small areas. It was mined and used, to a small extent, with charcoal for iron smelting in Buckhorn Furnace, but, as the results were not favorable, this practice was soon abandoned. The old entries are seen near the furnace stack, and they lie about 70 feet below the Ferriferous limestone. No good section of the rocks was obtained, but Luther Rankin reports the Tionesta coal in this locality to be 1 foot 6 inches in thickness.

Washington Township.—The best development of Tionesta coal found in Lawrence County is along Brady Creek, in Washington Township, where the coal is regularly mined for a part of the local supply of domestic fuel. The member is quite persistent, however, across the township, but in some places the bed is traced more by its clay than by the coal itself, for this is very thin and shaly. In local areas in the northern part of the township the coal is completely replaced by sandstones. Along the Cincinnati, Hamilton & Dayton Railway, northeast of Olive Station, the Tionesta coal, somewhat thin and broken, was exposed near the track level. The section obtained follows:

		Ft.	In.
Shale		5	--
Coal, good	*Tionesta*	--	6
Clay		--	3
Coal, good		--	9
Clay, good, plastic		3	--

Near the head of Olive Creek the coal is reported by Thurman Donley to be in one block 1 foot 6 inches thick. It has been worked in a small way here for local use.

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[1] Geol. Surv. of Ohio, Rept. of Prog. for 1870, p. 191.

Near the mouth of Hawkins Hollow, east of Bloom Furnace, in Section 28, this coal has been worked for local use. No good section of the rocks in the interval to the limestone was obtained, but the distance is 70 feet, aneroid measurement. The structure of the bed is as follows:

		Ft.	In.
Shale, dark		5	--
Coal, good	*Tionesta*	--	6
Clay, plastic, good quality		1	9
Coal, bony		1	3
Coal, good		1	1
Clay, good		2	--

On the property of J. P. Hansgen, in Section 21, on Brady Creek, the coal was exposed for measurement. The record follows:

		Ft.	In.
Shale		21	--
Coal, somewhat bony	*Tionesta*	--	6
Clay		--	6
Coal, good		--	8
Clay		--	1
Coal, good		1	11
Clay		5	--

About one mile down stream, on the property of Kuhner and Gleam, the structure of the coal is as follows:

		Ft.	In.
Shale, black		7	--
Coal, somewhat bony	*Tionesta*	--	6
Clay, good, plastic		--	6
Coal		--	1
Clay		--	3
Coal, good		--	4
Clay		--	2
Coal, good		1	6

Just west of the old stack of Pioneer Furnace on Brady Creek, in Section 22, the blossom of the Tionesta coal was seen, but the structure of the bed could not be obtained. The interval from the coal to the Ferriferous limestone is 60 feet, and on this account the coal is locally known as the 60-foot bed. North of Brady Creek the coal thins to a few inches except in the vicinity of Monroe Furnace in Jackson County, where it is well developed. The following section, made at Monroe Furnace, is given in order to show the position of the Tionesta coal with reference to the Ferriferous limestone:[1]

	Ft.	In.
Limestone, *Ferriferous*	5	--
Dark clay shale	1	--
Coal (reported)	3	--
Not exposed	53	--

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[1] Geol. Surv. Ohio, Rept. Prog. for 1870, p. 159.

	Ft.	In.
Sandstone, containing iron ore and *Spiriferae*, and *Producti*	6	--
Clay shale	4	--
Coal, with two thin slate partings, *Tionesta*	3	6

Near Washington Furnace, in the northern part of this township, the interval occupied by the coal and shale is taken by sandstones.

Economic Value of Tionesta Coal

Owing to the character of the overlying strata, the Tionesta coal is known locally as the "Slate" bed. The roof material of this member, in the northern part of Lawrence County, is a dark tough shale, under which mining is quite safe, as any give or break of the roof may be detected easily by sounding. Further, this kind of a roof allows a large percentage of the total coal to be mined. The floor of the Tionesta bed is a siliceous clay, which gives firm support for the posts and pillars. The bed, however, has some objectionable mining features. When the coal has sufficient volume for regular drift mining it is broken up into two or more coal benches, separated by clay or clay shale partings, the weight of which often exceeds that of the coal. Under these conditions, also, the coal mines dirty. The lower or main coal bench is everywhere of fair quality, but the upper benches are in many places somewhat impure. This member is also uncertain in extent and volume, which further limits its importance. On the whole the character of the Tionesta coal in Lawrence County is not such as to justify mining in a large way at present. It is important, however, for its contribution of fuel for local needs.

The Tionesta coal resembles the two Mercer coals in many respects, but it is less pure than the highest member of Upper Mercer. The coal in the benches has a blocky structure, which allows the fuel to be mined in lumps, with only a small loss in fine material. It is a free-burning fuel, and is moderately low in ash, which is clay-like in character. The soot produced during the combustion of the coal is not troublesome; hence it is liked for domestic purposes. It contains more sulphur than the underlying Mercer coals, but much less than the Clarion coal of the Allegheny formation. The sulphur in the coal is in the form of iron disulphide, and is distributed irregularly along the bedding planes. When all properties are considered, the Tionesta coal is a very good domestic and general purpose fuel. The operators of Buckhorn Furnace experimented with this coal for iron smelting, but their tests were not satisfactory.

Economic Value of Tionesta Clay

The Tionesta clay lies directly below the Tionesta coal. When normally developed this clay is light colored, and quite free from fluxing impurities, but it is nearly everywhere siliceous in character. The thickness of the bed shown on the outcrop is 3 feet 6 inches at Lawrence Furnace, 3 feet near Olive Furnace; 5 feet in the northwestern part of Decatur Township; 5 feet on the Hansgen property, on Brady Creek, and 5 feet in the northwestern part of Washington Township. In Elizabeth, Decatur, and Washington townships the average thickness of the clay is nearly 4 feet, while that of the overlying coal is about 1 foot 8 inches. Considered conjunctly, these beds are worthy of attention for ceramic purposes. The clay is well fitted for high-grade building brick, and it may be employed also in the manufacture of stone ware, paving block, and sewer pipe. In some localities this clay assumes the phase of a clay-bonded sandstone, which may be utilized for acid refractory ware. The Tionesta clay at present is not worked at any place in Lawrence County.

Economic Value of the Shales Above the Tionesta Coal

Many feet of shales of good quality for ceramic products are shown in the interval from the Tionesta coal to the Clarion clay. The shales in the upper part of this interval are in the Allegheny formation, but as there is no definite break in the deposits, and as the composition of the shales throughout the entire interval is much the same, they will be considered at this place. All the gradations can be found from a soft fine-grained gray shale, or a plastic clay to tough blue shale, dark fissile shale, carbonaceous shale, black band ore, bony coal, or sandstone.

Some of these varieties are unsuited for ceramic purposes. The tough thin-bedded blue or black shales often spall when subjected to heat. In burning ware made from such shales this action may completely disrupt it. Shales with high iron content fuse at low temperatures under reducing heat, as the iron oxides, which are reduced from the higher to the lower state, attack the silica to form low fusing silicates. Carbonaceous shales, with considerable iron oxide, cause trouble in burning, as they act much the same as the shales with the high iron content under reducing heat conditions. If the carbon is not oxidized at low red heat, it reduces the iron with the formation of iron silicates or slags, which, by flowing at moderate temperatures, deform the ware.

The varieties best suited for ceramic ware are the soft gray or ordinary shales, the arenaceous shales, and the clay shales. The drying and burning shrinkage coefficients of ware made from the different varieties of shales vary greatly. The total shrinkage in ware made from the fine-grained shales, or those high in fluxes, is generally sufficient to cause warping or checking of the ware. Coarse-grained arenaceous shales have low shrinkage usually, and make ware that retains its shape well through the drying and burning stages. The shrinkage of the clay shales is about intermediate between the fine-grained and the arenaceous shales. The fine-grained shales generally vitrify early to a dense mass. The arenaceous shales, where the proportion of sand is large, produce a porous body. Clay shales generally vitrify to a good dense body, but not as early as the fine-grained varieties.

The color developed in the ware made from the shales is also of importance, and is due largely to the quantity and disseminated condition of the iron, to the quantity of lime and clay substance, and to the state of oxidation and vitrification. For paving brick, color and texture are important, but texture is by far the most so. A dark color is usually wanted, as this seems to indicate a better state of vitrification. The texture must be such that the brick are tough, or will withstand long abrasive strains. Toughness in ware is secured where two classes of components are active; one class is made up of those materials that fuse and bond, and the other of those that remain rigid or unaffected. When these classes of components are properly adjusted, the texture of the ware is stony and dense. Ware of this character is very tough and durable. Where the mass vitrifies to a glass, the ware is brittle, and where no vitrification takes place, it is porous and fragile. Shales containing coarse sand are well suited for this grade of ware, as the finer parts vitrify, while the coarser particles remain unaffected. Such shales go to a good dense, tough mass, with low shrinkage, and generally with good color. Mixtures of shales and clays also give good results, as the shale vitrifies much earlier than the clay.

For sewer pipe the materials must have practically the same qualities as for paving brick. The ware must be tough to withstand shipping and handling; further, it must be vitrified to prevent absorption and abrasion. The color desired by the trade varies from dark red to brown or to nearly black.

Almost any shale may be used in making common brick, as color and shape are of little importance. For wire cut, or pressed building brick, shape, texture, and color are of value. The brick should have straight faces and edges. Warped, dished, or checked ware is very undesirable, as it does not lay up well in the wall. The trade at present prefers a partially or completely vitrified brick, on account of the low absorption. The color should be pleasing to the eye, but the shades desired vary with the individual taste.

Roofing tile should be strong and tough to withstand the strains. Both semi- and completely vitrified tile are found on the market. A good bright cherry red is the color most desired. Weathered shale is better fitted for this class of ware than the unweathered, for in the former the iron is oxidized principally to the ferric state, the fluxes are low from leaching, and the carbon has been largely removed by oxidation.

Each stratum of shale should be tested to find for what particular ware it is best fitted. Mixtures of the different shales found in the same interval should also be made and tested. In these tests the following points should be noted.

Preparation for the Kiln

Ease of Grinding.—Most shales require grinding or long weathering to reduce them to the necessary state for working into ware. The dry pan is the most common machine employed for the reduction of the material, but chasers and wet pans are used in some places. For most shales the dry pan is the cheapest and most efficient method. A 9-foot dry pan will reduce from 50 to 100 tons per day of ordinary shale. The kind and amount of grinding machinery necessary for a certain capacity of plant depends on the ease of reduction.

Ease of Developing Plasticity.—The ease of developing plasticity determines the method to be followed in the preparation of the ground shale for its formation into ware. In the dry processes a certain degree of steaming or aging is necessary, while in the stiff and soft mud process pugging only is required. The extent of this action depends on the ease of developing plasticity, which in most shales is readily produced.

Ease of Forming Into Ware.—The forming or manufacture of the materials into ware is accomplished in several ways. Hand molding for common brick is occasionally practiced. No difficulty is experienced, as the soft mud used is easily shaped into the desired forms. Soft mud machinery is also used to a limited extent. Stiff mud machinery is the common method used in the manufacture of brick, sewer pipe, and roofing tile. The main point is the behavior of the mud as it flows through the dies. When the column is formed by the auger machine, laminations, cracks, and unequal densities are to be observed. Less lamination occurs when the plunger machine is used. In the dry process filling out the corners and bonding the mass are the main results to be accomplished.

Drying Behavior.—Checking and warping are vital points, as these defects make the ware unmarketable. They are produced by the strains set up in the ware due to drying, or to the manner of making, or to both. Auger machine-made ware shows these defects most. The drying shrinkage should be carefully measured. When this is high, checking and warping usually develop either during the drying or the burning of the ware. This defective ware may amount to several per cent of the total output. The rate and method of drying should be determined, as the kind and capacity of the drier used depend on these. As a general thing, ware made from the coal formation shales dries quickly and safely. The toughness of the dried ware should also be taken into account, as the breakage in handling, when the ware is fragile or tender, is an important item of loss.

Scumming.—This is important, only, where the color of the burned ware must be considered. In face brick and roofing tile it is a serious defect, as the discoloration is offensive to the eye. But little attention is paid to it in sewer pipe and in paving brick. It is caused by the soluble salts in the materials being deposited on the surface of the ware during the drying process.

Burning Qualities

Temperature and Range of Vitrification.—That temperature at which the fluxing or bonding components have combined, with those giving rigidity to the mass to form the strongest and best developed structure, is considered in clay working the vitrification temperature. The structure of the body, as previously stated, depends on the relative quantities of these two classes of components. When the fluxing components are low, the body will be open and porous; when high, it will be stony or even vitreous. There is one temperature at which the structure of the body is best developed, and this temperature depends principally upon the composition of the ingredients.

The range of vitrification is that period in the burning which begins with incipient vitrification and extends to complete vitrification, or to where the ware softens and deforms. During this period the ware has a good structure, while below it the ware is soft and porous, and above it the product is vitreous and deformed. This range varies with the composition and with the texture of the different materials. If the range is long, little difficulty will be experienced in burning the ware, but if short, the danger of over or under burning is greatly increased.

Structure of Mature Body.—The structure of the body required varies somewhat for the different classes of ware, and also for different grades in some of the classes. For paving brick it should be dense and stony, as they must be hard, tough, and non-absorbent. Much the same structure is demanded for sewer pipe, and for roofing tile. For the better grades of building brick the trade at present requires a well vitrified body especially for outside work. The demand is for brick that absorbs but little if any water, and that does not discolor easily. For filler brick an open porous structure is generally preferred.

Burning Behavior.—Warping, dishing, and checking, during the burning process, depend largely on the strains set up in the ware during the drying process, augmented by strains due to heat action. The kiln strains are softening during the water smoking and vitrification periods, and fire shrinkage. The total drying and fire shrinkage of shales is usually from 1 to 1½ inches per foot. Shales contain more or less carbonaceous matter which may cause trouble during the burning, especially if the carbon content is high, or if the body is very dense. This carbon must be oxidized at low red heat, or it causes a reduction of the iron oxide from the higher to the lower state, which then attacks the silica to form low fusing slags. This chemical and physical action causes bloating and deformation of the ware.

The color of ware made from shale depends on the iron content, on its state of oxidation produced during burning, and on the alkaline earths present. The iron oxide in shales varies ordinarily between 5 and 10 per cent. Ferric oxides are red, while the ferrous oxides or their compounds are dark. The color of the ware depends on the state of oxidation, which may be varied by the method of firing. For the production of a red color an "open" fire with excess of air is required, and for that of the dark colors a "tight" fire with insufficient air is necessary. The finish or dark glaze required for paving brick is produced by reducing conditions during the later part of the burn.

The various strata in the interval have not been tested by the Survey; so definite information on them cannot be given. Deposits should be thoroughly tested to find for what particular wares they are best fitted before any development is undertaken. Much expense and labor can be avoided by so doing. Lawrence County has a wealth of clay well suited for the manufacture of high-grade building brick, and sewer pipe, and of shales which are superior for paving brick and roofing tile.

An analysis of the shales below the Ferriferous limestone at the Superior Portland Cement Company's plant is reported by Mr. E. C. Switzer as follows:[1]

Silica, SiO_2	55.04
Alumina, Al_2O_3	29.36
Ferric oxide, Fe_2O_3	2.10
Lime, CaO	.50
Magnesia, MgO	.91
Ignition loss	11.95

A partial analysis of the clay shale below the Clarion clay at Bartles Station is reported by Mr. E. B. Williard as follows:[2]

Silica, SiO_2	62.63
Alumina, Al_2O_3	24.69
Ferric oxide, Fe_2O_3	1.75
Lime, CaO	1.00

The ceramic industry is poorly represented in Lawrence County, although many conditions are quite favorable for the success of clay product enterprises. The quantity of the materials is large, and the quality good; further, the cheap coal, of which the county produces large quantities, could be used as fuel, thus affording the best possible market for this material. When properly selected or mixed large deposits of these shales are well fitted for the manufacture of paving and building brick, sewer pipe, and roofing tile. In the manufacture of paving brick the plants in this region would have to compete with the Portsmouth plants, which are well located, but have a costly fuel supply. For red brick, sewer pipe, or roofing tile, the competition would not be severe.

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[1] Personal letter, Feb. 28, 1913.

[2] Personal letter, March 7, 1913.

ALLEGHENY FORMATION.

The Allegheny formation is the most important division of rocks appearing at the surface in Lawrence County. It begins with the Brookville or No. 4 coal and ends with the Upper Freeport or No. 7 coal. Other well known members are the Clarion coal, Ferriferous limestone and ore, Lower Kittanning coal and clay, Middle Kittanning coal, and Lower Freeport coal. The rocks of this formation are best exposed in Upper, Hamilton, Elizabeth, Decatur, and Washington townships, although they are present also in Perry, Fayette, Lawrence, Aid, Symmes, and Mason townships.

BROOKVILLE, CONWAY, OR No. 4 COAL

In Lawrence County the Brookville coal, locally known as the Conway, is generally wanting, or is represented only by a stain, but in a few localities in the southern part it thickens to 12 or 18 inches. This coal has been mined along the outcrop at a few places in Upper Township, north of Ironton, but the bed is of little importance at present. It is exposed in the road tunnel just north of Ironton, where the following section was taken:

	Ft.	In.
Coal, *Lower Kittanning*	3	--
Covered, aneroid measurement	25	--
Limestone, *Ferriferous*, seen a short distance north	2	--
Covered, aneroid measurement	11	--
Sandstone, massive	20	--
Disconformity.		
Shales with ore nodules	7	--
Coal, *Brookville*	1	--
Clay, light	1	--
Clay shale	4	--
Sandstone, aneroid measurement	54	--
Shales, with thin coal band	2	--
Ore, *Upper Mercer*	2	--
Clay	1	--

North of the tunnel the Brookville coal was observed on the outcrop at a few places, but the bed was thin and impure. In the northern part of the county the coal, in most of the area, is replaced by thick sandstones. As the coal is thin, and as the associated beds have no practical value, the member will not be traced in a detailed way. The thin ore bed at this horizon was mined to a very small extent for the charcoal furnaces. The deposits are very local, and the quality of the ore poor. The position of the Brookville coal is from 15 to 35 feet below the Ferriferous limestone.

CLARION OR HECLA SANDSTONE

The position of the Clarion or Hecla sandstone is between the Brookville and Clarion coals. The thickness of the member varies from place to place, but it is usually from 15 to 30 feet. This sandstone extends northward from the Ohio River across Upper, Hamilton, Elizabeth, Decatur, and Washington townships into Jackson County. As many sections showing the position and thickness of the Clarion sandstone are given elsewhere in this bulletin they will not be repeated here.

Economic Value

From the Clarion or Hecla member most of the sandstone used in building and lining the charcoal furnaces in Lawrence County, and also in Jackson, was obtained. Jefferson Furnace, near Oak Hill, Jackson County, the only active charcoal furnace in Ohio at present, has been relined with this material for over 60 years. The rock has excellent, fire resisting qualities, and is chemically constituted to withstand the action of acid slags. In Lawrence County the deposit of Clarion sandstone near Coalgrove is worked for shipment by John Peters, and it is known locally as "fire stone". This sandstone has a light yellow color, and is composed of quartz and feldspar sand of medium sized grains, with a small quantity of clay and iron oxides for the bonding component. In conjunction with a dense sandstone called a ganister, and found at the base of the Clarion clay, the Clarion sandstone is mined by stripping and prepared for the market. The material is sold to the trade both in a block form and in a crushed state. A small quantity of clay is usually added to the natural stone before it is ground in the dry pan.

An analysis of the sandstone, made by W. M. Barnett, shows that it contains about 88 per cent silica, while two analyses of the prepared material, also made by the same person, are compared below with that of a mica schist, which is used in steel works for the same purpose as the sandstone:

	Prepared material. Coalgrove.	Prepared material. Coalgrove.	Mica schist.
Silica, SiO_2	80.70	83.00	85.36
Alumina, Al_2O_3 Ferric oxide, Fe_2O_3	14.20	11.51	11.44
Lime, CaO	.28	.12	.14
Magnesia, MgO	1.70	3.14	trace.
Ignition loss	3.00	2.70	1.35

The material is used in lining cupolas, Bessemer converters, and ladles. The principal markets are the steel plants at Ashland, Kentucky, and at Columbus, Ohio. The output of both the prepared and natural sandstone and ganister is about 5,000 tons per year.

CANARY ORE

The Canary ore lies at the base of the Clarion clay, and is found at only a few places in Lawrence County. It is a kidney ore of a yellowish color, and is low in iron. The bed was worked, to a small extent, by stripping, during the active period of the charcoal furnaces. At present the Canary ore has no value worthy of consideration.

CLARION COAL AND CLAY

In Lawrence County the Clarion coal is found in good development only in Washington and in northern Decatur townships. From central Decatur Township south to the Ohio River, the position of the member is marked by a thin stain of rotten coal or carbonaceous clay. The underlying Clarion clay, however, in this county, reaches its maximum thickness in the area south of the coal field. In fact, the clay is usually thin and siliceous where it is overlaid by coal. The Clarion clay is found not only in Washington and Decatur townships, but also in Elizabeth, Hamilton, and Upper. The coal lies directly below the Ferriferous limestone, or about 30 feet above the base of the Allegheny formation. The normal position of the Clarion clay is directly below the coal, but owing to the absence of the coal bed in the southern part of the county it lies just below the Ferriferous limestone. See Map IV facing page 318.

Upper Township.—In Upper Township the Clarion coal is marked only by a stain, but the clay has normal development in most of the area. Further, at the base of the clay, there is present in local districts a hard siliceous material which is called ganister. A section taken on the John Peters property, near Coalgrove, shows the relation of the Clarion clay and ganister to other members. The measurements follow:

	Ft.	In.
Limestone, *Ferriferous*	5	--
Clay, siliceous, plastic, *Clarion*	8	--
Sandstone, irregular, ganister	8	--
Sandstone, *Clarion*, called "fire stone"	10	--

This ganister is local in extent, but it is found also in small areas at other places in the county north of this. At the plant of the Ironton Portland Cement Company, A. C. Steece reports that the Clarion clay is from 6 to 10 feet in thickness, and is of good quality for brick making. On Hog Run the clay is about 8 feet in thickness, and the underlying ganister, which is locally developed, is from 1 to 2 feet. In the northern and western parts of the township the Clarion clay is very unsteady, and the ganister was not observed.

Perry Township.—The Clarion clay is present in places along the courses of Ice and Little Ice creeks, in the western part of Perry Township, but the coal is wanting. When the clay is present, it is from 3 to 8 feet in thickness, and quite siliceous in character. The ganister has been worked near Forestdale for the steel plants at Ashland, Kentucky. On Little Ice Creek north of the Dearing road, on the property of Charles Schaefer, the beds where exposed measured as follows:

	Ft.	In.
Clay, *Clarion*	3	--
Sandstone, ganister	1	8
Sandstone, bluish gray, also used as ganister	4	--

Hamilton Township.—The Clarion coal is wanting in all of Hamilton Township, while the clay is present only in isolated areas, and is seldom more than 3 or 4 feet in thickness. It is of the usual siliceous character, and gradates into sandstones. The position of the beds is well toward the summits of the main ridge.

Elizabeth Township.—The horizons of the Clarion coal and clay are above drainage in nearly all of Elizabeth Township. Their positions are near the summits of the high knobs on the main ridges in the western part, but owing to the descent of the rocks to the east and south they are at drainage level along the courses of the streams in the eastern part. The Clarion coal is marked only by a smut streak, but the Clarion clay is present in force in all the township except that part south of Little Pine Creek and west of Pine Grove Furnace. In the northern and eastern parts of this township the clay has excellent volume and continuity; in fact, it is better represented here than in any other part of Lawrence County. At Lawrence Furnace the Clarion clay is quite thick and is well fitted for ceramic uses. It is plastic, light colored, somewhat siliceous, and is low in iron and other fluxing compounds. A measurement obtained just east of the furnace is given below:

	Ft.	In.
Limestone, *Ferriferous*	7	--
Coal stain, *Clarion*	--	2
Clay, light, plastic, *Clarion*	8	--

At the mines of W. R. Maxey, one mile west of Lawrence Furnace, the Clarion coal is represented by about 6 inches of black carbonaceous material, but the Clarion clay, the lower part of which is very siliceous, is 9 feet in thickness. Near the head of Darby Creek the clay was again well exposed for measurement, and the thickness is 7 feet. The following record was taken at the mines of E. B. Willard, near Bartles Station:

	Ft.	In.
Limestone, *Ferriferous*	6	--
Clay, plastic, good, *Clarion*	6	--
Shales	12	--

Decatur Township.—In a general way the Clarion coal has excellent volume and continuity in Decatur Township north of a line drawn from east to west through Moulton, while south of this the member is marked only by a thin bed of decayed coal or by a smut streak. The Clarion clay, however, is best developed in the area in which the coal is wanting. The horizons of the beds are found well up on the hills in the western part of the township, and pass from view near the headwaters of the streams that rise on the main ridge, which extends along the eastern border. At the mines of Michael Riley, near Center Station, the Clarion clay measures 5 feet in thickness, but the coal is scarcely represented. In the southwestern part of the township the following

MAP IV.

Coal - -)	(- -	5
Clay, siliceous, *Clarion*	4	- -

the Clarion clay measures 3 feet in thickness, but the coal is scarcely represented. In the southwestern part of the township the following measurements were obtained at the mines of the Superior Portland Cement Company:

	Ft.	In.
Limestone, *Ferriferous*	7	--
Shale	--	8
Coal streak, *Clarion*	--	1
Clay, *Clarion*, plastic, siliceous	5	4

Near the head of Bear Run, E. C. Switzer reports the Clarion coal to be 1 foot 3 inches in thickness. Just across the main ridge north of this, at the head of Young's Branch, a heavy blossom of this coal is exposed in the bed of the stream. The coal was not sufficiently solid for measurement, but Luther Rankin stated that the bed under cover was 4 feet in thickness. The member is somewhat unsteady in this locality, but the blossom of the coal was observed at a few places on the hill west of this stream, near the mouth of which the record given below was obtained:

		Ft.	In.
Limestone, *Ferriferous*		8	--
Shale, draw slate		--	4
Coal	*Clarion*	--	9
Clay		--	5
Coal		2	1

In the hills east of the creek the coal was not seen, although the member, Mr. Rankin states, has fair volume at a few places. At the head of Howard Run the Clarion coal has been mined, but, as the entries had fallen, no section could be obtained. William Clutts reports the total thickness of coal and partings to be nearly 7 feet. In Buckhorn Hollow the blossom was seen at several places, and the coal was formerly mined in the bed of the creek near the head of the hollow. A. J. Goody reports that the Clarion coal is well developed near the head of the hollow, but that it is thin or wanting towards the mouth. Further, he states that it thins by replacement of the upper coal benches by sandstones. West of Moulton the sections show 3 feet of clay, but no coal below the limestone. In Branch Hollow, southwest of Moulton, the coal is wanting, but the clay is present. The section obtained near the mouth of Painter Creek shows that the Clarion coal has normal volume, and that the clay, although somewhat siliceous, is 4 feet in thickness. The structure of the rocks is as follows:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Shale, draw slate		--	2
Coal	*Clarion*	1	1
Clay		--	6
Coal		1	7
Clay		--	1
Coal		--	5
Clay, siliceous, *Clarion*		4	--

Near the head of Painter Creek, where the coal passes below drainage, it has the following structure:

		Ft.	In.
Limestone, *Ferriferous*		5	6
Coal	*Clarion*	1	1
Clay		--	6
Coal		1	6
Clay		--	1
Coal		--	7
Clay		2	--

On the north side of the hill, south of Painter Creek, the coal is reported by Frank Smith to be well developed, while on the south side of the hill the bed, he states, thins to 15 inches, or even less. It persists to near the center of the hill and then thins rapidly. In the hill north of Painter it has normal volume and excellent continuity. Mr. H. L. Moulton reports the Clarion coal in this region as follows:

> It is well developed on Painter Creek. East of the railroad, south of Painter Creek, it is developed in Carmen Hollow, which is west of Jep Station, but is wanting in the hills south of this along the pike. The mines of the Hall Coal Company, which are idle at present (1912), are located east of Jep Station. The main entries are in the Painter Creek hill to the east, and the coal has practically the same volume as that found on Painter Creek. On the hill west of the railroad some mines have been worked. The coal has a normal thickness south of this to Carmen Hollow. An east and west line through Moulton marks practically the southern limit of the Clarion coal in Lawrence County.

At the mines of the Buckhorn Coal Company, on Nigger Creek, the structure of the Clarion coal is as follows:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Coal	*Clarion*	1	--
Shale		--	6
Coal		1	8
Shale		--	2
Coal		--	6
Clay		2	--

Up Nigger Creek a thick blossom was seen in several places, but the coal was not found opened. Near the head of the creek, Alfred Malone reports the total thickness of the coal and parting to be from 3 feet 6 inches to 4 feet. The following section was taken in the McGugin mine, near Olive Station, in northern Decatur Township:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Shale, draw slate		--	2
Coal	*Clarion*	1	--
Clay		--	6
Coal		1	7
Clay		--	1
Coal		--	8
Clay		--	8
Coal, generally bony		--	8
Clay		1	--

Symmes Township.—The Clarion coal appears in the bed of Buffalo Creek near the Rehmer School, in Symmes Township, and this is its most eastern exposure in Lawrence County. John Rehmer states that the coal is 1 foot 6 inches in thickness, and that a small quantity of fuel has been obtained here by stripping. No drill records showing the character of the member under cover in this area were obtained, but the continuity of the bed, where it passes from view in the northeastern part of Decatur Township, would indicate that there may be a small field of good coal in northwestern Symmes Township.

Washington Township.—The Clarion members extend from Decatur Township northward across Washington into Jefferson Township, Jackson County. The beds are found near the summits of the main ridges in the western part, but, owing to the dip of the rocks at the east and south, they pass below cover west of the high ridge that extends along the eastern border. Both coal and clay are quite constant throughout the area, although at a few places they are replaced by sandstones. Further, in local areas, the upper bench of coal is wanting, or is in a decayed condition. The field of Clarion coal in Washington Township is an important asset to the mineral resources of Lawrence County. As the Clarion clay is usually thin and somewhat siliceous, and as it ranks far below the great overlying Lower Kittanning bed, its utilization is practical only where mined along with the coal, and where other conditions are favorable for the success of ceramic industries. Near the head of Olive Creek, in Section 35, the Clarion coal was seen in the road that leads from this stream to Indian Creek. At this place the coal is thin, as is shown by the following section:

	Ft.	In.
Limestone, *Ferriferous*	6	--
Coal blossom, *Clarion*	1	--
Clay, *Clarion*	3	--
Sandstone, light color, ganister	4	--

About one mile further north, on Olive Creek, in Section 36, near the track of the Cincinnati, Hamilton & Dayton Railway, this coal is only 1 foot thick. James Donley reports the Clarion coal to be thin from Olive Station east along the Cincinnati, Hamilton & Dayton Railway to where it goes under cover south of the tunnel, but to have normal volume from Olive Furnace west to the Baltimore & Ohio Southwestern Railroad. North of Olive Furnace, along the Ironton pike, the coal has been mined, and Mr. Donley reports it to be 3 feet 6 inches in thickness. Near the head of Brushy Fork, in Section 28, the structure of the coal is as given below:

	Ft.	In.
Limestone, *Ferriferous*	6	--
Shale, draw slate	--	6

		Ft.	In.
Coal	*Clarion*	1	--
Clay		--	5
Coal		2	--
Shale		--	2
Coal		--	5
Clay, *Clarion*		3	--

On land of Albert Tracy, north of Brady Creek, in Section 16, the following record was taken:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Shale		--	6
Coal	*Clarion*	1	2
Clay		--	6
Coal		1	6
Shale, with pyrite		--	1
Coal		--	7

The coal is well developed on Brady Creek, and has been worked considerably for local use. Near the old stack of Pioneer Furnace several mines have been operated, but as they have fallen no measurement could be obtained, except on the outcrop, where the blossom of the coal was 3 feet thick. Near the head of the creek, at the Town House on the Ironton road, a section of a mine shows the structure of the bed as follows:

		Ft.	In.
Limestone, *Ferriferous*		5	--
Shale, draw slate		--	3
Coal	*Clarion*	1	2
Clay		--	7
Coal		1	7
Clay		--	1
Coal		--	7
Clay		1	--
Coal		--	5

In Section 22, on the J. P. Hansgen property, about one mile east of Peach Orchard School, a record, taken on the outcrop, and given below, shows the thickness of the Clarion clay in this locality:

	Ft.	In.
Limestone, *Ferriferous*	7	--
Coal blossom, *Clarion*	3	--
Clay, siliceous, *Clarion*	5	--
Sandstone, clay-bond light	5	--

At the mines of the Bear Run Mining Company, east of Globe switch, in the northern part of Section 16, the structure of the Clarion coal, which is regularly mined in conjunction with the Ferriferous limestone, is shown in the following record:

	Ft.	In.
Limestone, *Ferriferous*	8	--
Shale, draw slate	--	2

		Ft.	In.
Coal	Clarion	1	--
Clay		--	6
Coal		1	8
Shale		--	1
Coal		--	6
Clay		1	--
Coal, bony, containing pyrite		--	8
Clay		--	8
Coal, bony, containing pyrite		--	8

East of Eifort it has been mined for years for local use. No good section was obtained, but the coal is reported by John Haines to be well developed. A section in a mine of the Portsmouth Refractories Company, in Spencer Hollow, is as follows:

		Ft.	In.
Limestone, *Ferriferous*		7	6
Shale, draw slate		--	3
Coal	*Clarion*	1	--
Clay		--	5
Coal		1	8
Clay, with pyrite		--	1
Coal		--	6
Clay, flint, good		2	--
Coal, bony		---	3

Along the road that leads from Black Fork to Spencer, in the eastern part of Section 3, the Clarion clay was well exposed for measurement. The relation of this to other beds is shown in the following section:

	Ft.	In.
Limestone, *Ferriferous*	5	--
Coal blossom, *Clarion*	3	--
Clay, good, siliceous, *Clarion*	6	--

Near the plant of the Cambria Clay Products Company, in Black Fork Hollow, the Clarion coal is well developed, and the Clarion clay assumes a flinty phase. These features are shown in the record given below:

		Ft.	In.
Limestone, *Ferriferous*		9	--
Shale		--	1
Coal	*Clarion*	1	3
Clay		--	4
Coal		--	10
Coal, bony		--	½
Coal		--	10
Clay, impure		--	2
Coal		--	6
Clay, flint, *Clarion*		2	--

The Clarion coal has normal volume in Irish Hollow and on the main ridge south of this. The flinty phase of the Clarion clay was also observed, but the deposits are somewhat local in extent.

Economic Value of Clarion Clay and Ganister

The clay on the Clarion horizon, as shown by the sections, is well developed, at least in parts of Lawrence County. In the southern portion of the county, as far north as Bartles Station, it has good thickness where the limestone is present, but farther north, where the coal overlies the clay, it is usually thin or siliceous. Near Spencer and Black Fork, in the northern part of Washington Township, a few feet of flint clay are found directly below the coal. The average thickness of clay in Elizabeth, Upper, and Hamilton townships is about 5 feet, with a maximum of 12 and a minimum of 2 feet. Where the deposit is thick the lower part is usually siliceous.

The clay is regularly mined and marketed at only one place in the county, and that is near Bartles Station, where E. B. Willard works it as a secondary product from the limestone mines. Crude clay is shipped from here to the fire brick works of the Charles Taylor & Sons Company, at Cincinnati, Ohio, and ground clay is also prepared for the iron and steel trade. A 9-foot dry pan is used for grinding. The total output is about 3,000 tons per year. A section of the mine shows the deposit to be 6 feet thick. Counting 60 per cent of the clay available in mining, the yield per acre would be 12,200 tons. The conditions for mining both clay and limestone are good, as the roof is a heavy sandstone. The analysis of this clay, furnished by E. B. Willard, is as follows:

Silica, SiO_2	55.20
Alumina, Al_2O_3	31.02
Lime, CaO Magnesia, MgO	.65
Iron oxide, Fe_2O_3	1.90
Alkalies, K_2O, Na_2O	2.06

At Lawrence Furnace the clay is 8 feet and the limestone 7 feet thick. The materials above the limestone are shales and clays, which form a poor roof for mining. The best method would be to leave 2 feet of the limestone in place for a roof, which would give 5 feet of stone and 8 feet of clay to be taken from the same entry. The cost of drilling, shooting, loading, and hauling in this case, for both stone and clay, would be about 30 cents each per ton.

In the northern part of the county, where the coal appears, the clay is not well developed, as it is usually thin or siliceous, except in the extreme northern part where a few feet of flint clay are found. A section on Painter Creek, in the northern part of Elizabeth Township, shows 4 feet of siliceous clay, and another on Olive Creek 3 feet. On Brady Creek, in Washington Township, the section on the Hansgen property gives 5 feet of siliceous clay. Two feet of flint clay are found in places along Spencer Hollow and along Black Fork Creek. In this area clay, coal, and limestone may be taken from the same entry. The partings between the coal benches are usually plastic clays of fair quality, yet little of this would be available, for in mining the coal the clay would be mixed with fine coal, slate, and sulphur compounds. Mr. D. D. Davis, president of the Ohio Fire Brick Company, Oak Hill, Ohio, who has tested this clay, reports:

> We have had no success with it in the making of fire brick. Its composition is fair, but the clay does not have the proper strength to withstand a high degree of heat; besides there is something in it that burns very brown, and discolors the brick. It is used by several fire brick producers as bonding clay, but we do not find it satisfactory.

The uses of this clay may be summarized as follows: It is not well fitted for the manufacture of high-grade refractory ware, and is inferior in quality to the Lower Kittanning clay found in the same region, or to the Sciotoville clay found farther west. At its best the ware made would be rated as low-grade, which would not compare with that made from either of the clays given above. The clay from the northern part of the area is considered by Mr. D. D. Davis to be not even a good bonding clay, while that from the southern area is of better quality, and is used for this purpose. The Clarion clay, however, is well fitted for the manufacture of building brick as it gives at maturity a good buff or iron mottled body, which is very resistant to weathering agencies and attractive to the eye. This use of the clay should be encouraged. Where the clay is quite siliceous in character, it has about the right composition for paving blocks. Such clays burn very dense and have excellent toughness or abrasive resistance. Owing to the association of the Clarion clay with the Clarion coal and Ferriferous limestone, this bed offers good opportunities for increasing the industrial wealth of Lawrence County.

Economic Value of the Ganister on the Clarion Horizon

The ganister deposits in Lawrence County are confined to isolated patches in Perry, Upper, Elizabeth, Decatur, and Washington townships. It is a dense light colored material very high in silica. It contains root marks of Lepidodendron and appears to have been formed at the beginning of the swamp period during which the Clarion clay and coal were laid down. The composition of the material is shown by the partial analysis of the dry ganister furnished by W. M. Barnett. The components determined are given below:

	Dried at 212°F.
Silica, SiO_2	97.60
Iron, Fe	.23

This material is prepared for the market by mixing three-fourths ganister with one-fourth clay, after which the batch is ground in a dry pan. The silica in the prepared material is shown by Barnett to be 74.10 per cent. The ganister from the deposits near Coalgrove is being used, and is pronounced satisfactory; in fact, it compares favorably with the Pennsylvania ganisters, which are largely used. The stone is low in iron oxides and in clay and has a high fusion point. Its acid character well fits it for use in acid steel work, for which it is used at Ashland, Kentucky, and at Columbus, Ohio.

Economic Value of Clarion Coal

At present in Lawrence County the Clarion coal furnishes only a small part of the local fuel supply, but as the Lower Kittanning, which is of much better quality and the main reliance at present, becomes exhausted, this bed will become important, as the total area of the field is about 25 square miles, of which at least 15 square miles is productive territory, and as the mining conditions are fair. The relation of coal and limestone is also of interest, especially in mining, for by working the coal first an efficient method of mining the stone is opened. The Clarion coal is important and well developed in the northern part of Decatur Township and in the whole of Washington, where it is persistent and regular. The average structure shown by the 13 sections, not considering the bony bottom layers seen in a few places, is as follows:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Shale, draw slate		--	2
Coal	*Clarion*	1	1
Clay		--	5
Coal		1	6
Clay		--	1½
Coal		--	6

This gives a thickness of 3 feet 1 inch for the coal, and of 8½ inches for the clay and draw slate, or a total of 3 feet 9½ inches, which is sufficient height for ease in mining. If mule or electrical power is used in haulage, some material from the bottom may have to be removed in the entries. This bed, 3 feet 1 inch thick, will yield, if 60 per cent are available, 3,400 tons per acre. The specific gravity of the mine run coal is 1.35.

The structure of the Clarion coal offers several obstacles to the successful mining and marketing of the fuel. The clay partings diminish the effect of the explosives, and require additional shots to loosen the several benches. Further, removing the partings from the coal and getting them out of the way increases the expense. Some fine clay always remains with the coal, and of course this diminishes the value of the fuel. If the mine is very wet the clay forms a plastic mud, which sticks to or coats the coal, and which, on drying, has a light color. Such fuel has a bad appearance. Naturally, it also adds to the per cent of ash. The significance of thick partings is shown by the fact that the coal in the Clarion bed weighs 2,341 pounds and the partings 992 pounds quare yard of surface. But the account is not all on the debit side. Where the bed is cut by hand or by machine, these soft clay partings are an advantage, as they are much softer than the coal. Further, by cutting in the clay all the coal is saved. Most of the fuel mined from this member at present is "bunkered" or "shot off" the solid.

The roof of the Clarion coal is the Ferriferous limestone, which under heavy cover is of excellent character, as it is very solid, and as the joints, if developed, are thin. Along the outcrop and under thin cover it is generally blocky in structure from weathering along the joints. In this case mud partings from a few inches to a foot or more in thickness are found between the blocks, and these make the mining both difficult and dangerous. Further, the coal in such places is often weathered and worthless. Generally a few inches of "draw slate," which is taken down, separates the coal from the limestone. The lower surface of the limestone is quite uniform; hence but few small rolls are encountered. The floor materials vary in different sections. It may be either soft clay, clay shale, sandstone, or siliceous clay, but generally it is the latter. Soft clays are poor floor material; for, where the pressure is great, the posts and coal blocks left for supports may be squeezed down into them. This tends to fill the entry ways with clay, the results of which require the tracks to be taken up and the clay to be removed. The area of coal left for ribs, stumps, and pillars must be much larger where floor materials are soft than where they are solid and firm. The sandstones and siliceous clays are excellent floor material. Where both a good roof and bottom are found a large per cent of the total coal in a bed is available. The Clarion coal in this region generally has both.

Soft clays are less expensive to remove from the entry ways for tracks and drains than the harder materials, but they are the source of more additional expense, because the tracks sink easily and require ballasting, and, also, the drains soon fill with material which must be removed. The floor of this coal is quite free from rolls or dips. Rolls cause wet places in the mine, or make expense in draining. The dip of the stratum should be considered, as ease of drainage and of haulage depends much on this gradient. The general dip is south of east; so the main entries should run in a northwesterly direction, which would allow the mine to drain without much expense. Further, under such conditions, the loaded cars will move down hill.

The associated materials are important. The Clarion coal has above it the Ferriferous limestone, which is well developed, and which is of good quality throughout the whole area, while the coal is underlaid by clays which are of fair grade and thickness in part of the territory. Coal, limestone, and clay may be taken from the same mine. The method followed is to mine the coal first, then remove the clay, and lastly "break down" the limestone, or a part of it. If the materials above the limestone make a poor roof, about two feet of limestone should be left. Under these conditions Mr. John M. Hanes, who has had extensive experience in this locality, reports the cost of mining, that is, for shooting, loading, and hauling, to be about 60 cents per ton for coal, and 30 cents per ton for limestone and clay.

Generally considered, the quality of the coal is rated low, as the sulphur and ash are both high, and as the latter clinkers freely. It should be classed as a free burning coal, but in this respect it is inferior to the Lower or Middle Kittanning fuels. It burns freely as long as the volatile matter is passing off, then the residue of fixed carbon burns slowly and with but little flame. The coal does not stand handling and shipping well as it is much jointed, and as the lumps are rather weak. The Clarion is a coking coal, and the product is of good quality when structure alone is considered. The cell structure is well developed, and the walls are thick and strong. The structure is such that it would be satisfactory for furnace use; for it would carry a heavy burden and have a large surface of carbon exposed to the gases. Coke was made years ago from this coal at Vinton Furnace in Welsh ovens for use in the charcoal furnace, but it proved unsatisfactory, owing to the high sulphur content. The remains of the old ovens and a pile of the coke made may be seen there at the present time. Mr. Wm. H. McGugin made a small quantity of coke from it at Olive Furnace. The physical properties of this product were good.

The sulphur in the Clarion coal occurs in the forms of organic and iron sulphides. In the processes of coking in use at the present time only about one-half the sulphur is eliminated, while the other half remains in the coke. The average sulphur in four samples from Lawrence County, determined by the Survey,[1] is 4.84 per cent, consequently, if only one-half were eliminated, and the yield in coke only 60 per cent, the sulphur in the product would be 4.03 per cent, which is far above the limit accepted at the present time for metallurgical purposes. The average ash in the four samples is 13.6 per cent, and if the coke yield were 60 per cent the final product would contain 22.70 per cent ash, which would make it practically unmarketable. The sulphur content specified in coke is usually 1 per cent or less, and the ash under 12 per cent. With the systems in use at present in the washing and coking of coal it is scarcely possible that this coal could be purified enough to make a suitable coke.

For the burning of clay ware, such as building and fire brick, the coal is not satisfactory, as it has a short flame. Color in building brick is largely developed by the direct action of the flame on the ware, and the bonding of the particles also seems to be more perfect where long flame coals are used as fuel in burning. This coal also burns rather dead, therefore, the high temperatures required in the burning of fire brick are obtained only with difficulty. The large sulphur content is also objectionable as it discolors the ware.

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[1] Geol. Surv. of Ohio, Fourth Ser., Bull. 9, p. 291.

The quality of the coal is shown by the following analyses:[1]

Mine of McGugin & Company, section 7, Decatur Township, Lawrence County. The sample was cut from an old entry where the coal was weathered. Sampled in August, 1901, by Professor Edward Orton, Jr.

Chemical analysis and calorific value of sample 65

Ultimate		*Proximate*	
Carbon	57.92	Moisture	6.34
Hydrogen	4.91	Volatile matter	35.30
Oxygen	13.40	Fixed carbon	40.95
Nitrogen	1.07	Ash	17.41
Sulphur	5.29		
Ash	17.41		

Calorific value
Calories, 5,967
B.t.u., 10,741

Mine of J. R. Edwards, section 23, Washington Township, Lawrence County. Sample cut 75 feet from entrance to mine where the coal was fresh. Sampled by Professor Edward Orton, Jr., in August, 1901.

Chemical analysis and calorific value of Sample 66

Ultimate		*Proximate*	
Carbon	63.32	Moisture	6.00
Hydrogen	5.26	Volatile matter	39.16
Oxygen	13.24	Fixed carbon	42.98
Nitrogen	1.22	Ash	11.86
Sulphur	5.10		
Ash	11.86		

Calorific value
Calories, 6,519
B.t.u., 11,734

Mine of McGugin & Company, Olive Station, Decatur Township, Lawrence County. Sample cut well under hill where coal was clean and bright. Sampled by Professor Edward Orton, Jr., in August, 1901.

Chemical analysis and calorific value of Sample 67

Ultimate		*Proximate*	
Carbon	60.22	Moisture	5.86
Hydrogen	5.06	Volatile matter	37.25
Oxygen	12.90	Fixed carbon	41.61
Nitrogen	1.18	Ash	15.28
Sulphur	5.36		
Ash	15.28		

Calorific value
Calories, 6,185
B.t.u., 11,133

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[1] Geol. Surv. of Ohio, Fourth Ser., Bull. 9, 1908, p. 180.

Mine of Isaac Hall, section 15, Decatur Township, Lawrence County. Sample cut one-half mile from entrance. Surface of coal has been exposed two months. Sampled by Professor Edward Orton, Jr., in August, 1901.

Chemical analysis and calorific value of Sample 68

Ultimate		*Proximate*	
Carbon	65.53	Moisture	6.11
Hydrogen	5.42	Volatile matter	38.43
Oxygen	14.28	Fixed carbon	45.52
Nitrogen	1.22	Ash	9.94
Sulphur	3.61		
Ash	9.94		

Calorific value {Calories, 6,643
B.t.u., 11,957.

The average calorific value for the four samples is 6,329 calories, which gives it a rating below the Lower or Middle Kittanning coals. For domestic use, coal with high sulphur content is objectionable, for in burning it gives off sulphur dioxide gas, which attacks the tissues of the throat and lungs. The average sulphur found in the Clarion coal is about 4.50 per cent, which occurs principally in the form of iron pyrite and organic sulphides. During combustion, the latter, and part of the former, goes to sulphur dioxide gas, which, escaping with the other waste gases, produces the injurious effects. For steaming purposes the Clarion coal has some undesirable qualities, the most objectionable of which are the corrosive action of the sulphur on metal and the clinkering of the ash. The action of sulphur dioxide on metals is given by Somermeier as follows:

> Upon the cooling of the flue gases the sulphur dioxide, formed during the combustion of the coal, unites with water and forms sulphurous acid, which as such or upon further oxidation to sulphuric acid has a corrosive effect upon metallic structures. The corrosive action takes place after cooling and the popular idea that sulphur in coal causes corrosion of boiler tubes, etc., by action of sulphur dioxide is largely without real foundation.[1]

Where high temperature is carried in the furnace, the corrosive action on the metal grates is due largely to the sulphur held in the fused ash. During the combustion of the coal the oxidation of ferric sulphide is generally incomplete, and ferrous sulphide and oxide are formed. Ferrous sulphide fuses at a low red heat and this, with the low fusing compounds produced by the ferrous oxide combining with the silica and alumina of the ash, forms fluid slags which, coming in contact with the metal where the air supply is limited, causes the corrosive action on the grates which are soon eaten away or become brittle and break. The ash of this coal clinkers readily. An analysis of a sample of ash is as follows:

Ferric oxide, Fe_2O_3	2.60
Silica, SiO_2	2.50

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[1] COAL, p. 7.

Alumina, Al_2O_3	1.80
Lime, CaO	.30
Magnesia, MgO	.06
Phosphorus, P	.005

The iron shown in the above analysis was principally in the form of ferric sulphide in the coal, which under reducing conditions goes to either ferrous oxide or sulphide or both. Considering the iron present as ferrous oxide the bases present are as follows:

Ferrous oxide, FeO	2.34
Lime, CaO	.30
Magnesia, MgO	.06
Total	2.70

The acids present are next given:

Silica, SiO_2	2.50
Alumina, Al_2O_3	1.80
Phosphorus anhydride, P_2O_5	.01
Total	4.31

The ratio of acid to base is 1.6, which is well within the slag ratio. Mr. P. D. Freer, of the Cincinnati, Hamilton & Dayton Railway, says:

> We have used this coal, but it does not give as good results as the Lower Kittanning; for the Clarion clinkers freely and apparently contains more foreign matter.

The Clarion coal in burning makes much smoke and soot. Unless the draft is strong, this soon fills the flue system, which then requires cleaning by hand or by burning wood. The normal ash of the coal is high, and it decreases the value of the fuel as it lowers the carbon content. The handling of this ash, both in the coal and when burned, is also an added expense. A summary of the points for the Clarion coal is as follows:

1. Sufficient thickness and regularity for ease in mining.
2. Roof generally very good.
3. Floor generally very good.
4. Associated minerals of value:
    a. Limestone.
    b. Ore.
    c. Clay.
5. Coking coal. No value at present.
6. Steaming coal.

Points against:

1. Bed in several benches separated by partings.
2. Coal mines dirty, owing to partings.
3. Heating value only moderate.
4. Ash in coal high.
5. Sulphur in coal high.
6. Ash clinkers at high temperatures.
7. Coal forms much soot in burning.
8. Quality of coal poor for general purposes.
9. Structure of coal weak. Breaks easily in handling.

FERRIFEROUS LIMESTONE AND ORE

The Ferriferous or Vanport limestone, and the Ferriferous or Baird ore, the next members found in the Allegheny formation, have contributed much to the prosperity and wealth of Lawrence County, and they bid fair to add materially to its revenue for many years to come.

Early in the development of the State these rocks brought the Hanging Rock Iron Region into prominence for its iron making as the 16 charcoal furnaces in this county drew all or a part of their supply of ore and flux stone from the Ferriferous members. Further, these beds have furnished, but to a more limited extent, a part of the burden for the 9 more modern stacks that have been erected in Lawrence County. Another use, the importance of which can scarcely be estimated, is that of the Ferriferous limestone for road building. Owing to the wide distribution of the bed, and to the excellent quality of the stone, the western half of the county is spanned with many miles of fine macadam roads, which add much to both the social and commercial welfare of the region. This limestone is also responsible for the establishment of the cement industry in southern Ohio. At present it is being used for soil enrichment.

Stratigraphy and Extent

The Ferriferous or Vanport limestone with the overlying Ferriferous ore is found on the average approximately 23 feet below the Lower Kittanning coal and directly above the Clarion coal. The members extend from the Ohio River northward across Lawrence County into Jackson and Gallia. They are best represented in Upper, Hamilton, Elizabeth, Decatur, and Washington townships, but they appear also in western Perry and on Buffalo Creek in the central part of Symmes. The members will now be traced in a more detailed way.

Perry Township.—In the southern part of Perry Township the Ferriferous limestone and ore passes below the bed of the Ohio River somewhere near the village of Sheridan. North of this a few small patches of limestone and ore are found along the lower course of Little Ice Creek and along Ice Creek east of the mouth of Sugar Creek. The limestone varies from 2 to 5 feet in thickness; while the ore on Ice and Sugar creeks is reported to measure from 4 inches to 1 foot.

Upper Township.—In Upper Township the Ferriferous limestone is very patchy and usually thin. The ore is somewhat more persistent than the limestone, but in the greater part of the area it is also replaced by sandstones. Near Coalgrove on the John Peters property the limestone is mined in a desultory way for road and other purposes. A general section of the rocks taken at this place and given below shows the relation of the limestone and ore to other beds:

	Ft.	In.
Ore, *Ferriferous*	--	6
Limestone, *Ferriferous*	5	--

	Ft.	In.
Clay, siliceous, *Clarion*	8	--
Sandstone, ganister	8	--
Sandstone, *Clarion*	10	--

North of this along the lower course of Ice Creek the limestone and ore are somewhat steady. The Ironton Portland Cement Company used this limestone for several years in the manufacture of their product, but at present they use the Maxville which has great thickness and high purity. A. C. Steece reports that in this locality the Ferriferous ore varies from 6 inches to 1 foot 6 inches in thickness, and that the limestone measures from 4 to 6 feet. Along Sugar Creek south of the Marion Road the limestone and ore are normally developed. Near the road tunnel just north of Ironton a small oulying patch of these rocks is found, while along Storms Creek both beds are unsteady. The limestone is present in patches along the course of the stream in the northern part of the township, while the ore extends with some wants well towards its mouth. Much the same conditions as these are found along the course of Little Storms Creek, for both members are seldom present in force.

Hamilton Township.—The Ferriferous limestone is wanting in eastern Hamilton Township and in the western part it is represented more often by irregular masses of flint than by limestone. The ore, however, is somewhat more persistent than the limestone and has about normal volume. This bed varies in thickness from a few inches to 1 foot 6 inches, but in places it is admixed with irregular masses of flint.

Elizabeth Township.—As we pass from the river townships northward into Elizabeth, both the Ferriferous members are present in force and with the characteristic development for which they are noted, also in Jackson and Vinton counties. The beds extend in nearly an unbroken sheet over all the township except that part west of Pine Creek, and that part south of Little Pine Creek and west of Pine Grove Furnace, in which areas the members are marked only by isolated patches of ore and flinty limestone. About one mile north of Royer Station at the limestone mines of the Hanging Rock Iron Company, the following measurements were made under favorable conditions:

		Ft.	In.
Ore	*Ferriferous*	--	5
Ore, calcareous		--	3
Limestone, *Ferriferous*		6	3

In local areas in this vicinity the ore has exceptional volume as it expands to as much as 4 feet in thickness and appears to replace the entire bed of limestone. Analyses show that the ore is of exceptional quality also. In the vicinity of Pedro both limestone and ore are quite well developed, but in the extension of the members eastward to Storms Creek the limestone in many places is flinty and thin, while the ore holds normal thickness. Where measured, the ore varied from 6 to 12 inches in thickness, but the limestone seldom exceeded 5 feet. Near Lawrence Furnace the limestone, where examined, was from 5 to 8 feet in thickness, while the ore was from 2 to 10 inches.

One mile west of Lawrence Furnace, at the mines of W. R. Maxey, the limestone measured 7 feet 10 inches and the ore 8 inches. In this locality, also, two irregular layers of ore are present in the shale that overlies the regular deposit of Ferriferous ore. These upper beds each average about 5 inches in thickness. At the head of Darby Creek the rocks exposed measured as follows:

	Ft.	In.
Coal blossom, *Lower Kittanning*	3	--
Clay	5	--
Shale and covered	15	--
Limestone, *Ferriferous*	6	--
Clay, *Clarion*	7	--

On Cannons Creek, east of Lawrence Furnace, the Ferriferous limestone is often flinty in character, but it has about normal volume. The ore varies in thickness from 1 inch to 1 foot. E. B. Willard mines the Ferriferous limestone by drifting near Bartles, where the following measurements were obtained:

	Ft.	In.
Ore, *Ferriferous*	--	8
Limestone, *Ferriferous*	6	--
Clay, *Clarion*	6	--

Near Center Station both the Ferriferous members have good volume, and have been mined in a large way. The limestone is from 6 to 9 feet in thickness, while the ore varies from 4 to 12 inches. On the main ridge, south of Center Furnace, both members are generally present in force. In Elizabeth Township, west of Pine Creek, small patches of limestone and ore appear on the high knobs on the main ridge east of Irish Hollow.

Decatur Township.—The importance of the Ferriferous members in Decatur Township is attested by the fact that at least 6 charcoal furnaces drew all or a good part of their supply of ore and flux stone from the beds in this area. The volume and continuity of the members are excellent, and the direct association of the Clarion coal with them in the northern part of the township also increases their worth. The members will now be described in a more detailed way in order that the main features of these rocks may be rightly understood. At the mines of Michael Riley, near Center Station, the following record, which shows about normal volume of the members in this vicinity, was obtained in the mines:

	Ft.	In.
Sandstone	15	--
Ore, *Ferriferous*	--	10
Limestone, *Ferriferous*	8	6
Clay, plastic, *Clarion*	5	--

In this locality the massive overlying sandstone forms an excellent roof for safety and ease in mining. These same general conditions also extend west of Center Furnace, where the following record was obtained at the mines of the Superior Portland Cement Company:

	Ft.	In.
Sandstone, massive	15	--
Shale	1	6
Ore, *Ferriferous*	--	7
Limestone, *Ferriferous*	7	--
Shale	--	8
Coal blossom, *Clarion*	--	1
Clay, *Clarion*	5	4

In Branch Hollow, southwest of Moulton, the Ferriferous limestone is somewhat patchy, and varies in thickness, when present, from 3 to 7 feet. The ore is quite steady, and is reported by David McFann to be about 1 foot in thickness. Further, the condition of the beds near Moulton is somewhat the same, while along the pike, near the head of Pine Creek, the limestone measured 6 feet. Near the mouth of Painter Creek, north of Moulton, the following record was obtained:

	Ft.	In.
Ore, *Ferriferous*, reported thickness	--	10
Limestone, *Ferriferous*	7	--
Shale	--	2
Coal and partings, *Clarion*	3	8

At the mines of the Buckhorn Coal Company, near the mouth of Nigger Creek, the ore, limestone, and underlying coal all have excellent volume. The record obtained follows:

	Ft.	In.
Ore, *Ferriferous*	--	10
Limestone, *Ferriferous*	7	--
Coal and partings, *Clarion*	3	10

In Buckhorn Hollow the limestone is usually thin, while in places it is wanting. The ore is rather steady, and in local areas is reported to expand to 2 feet or even more. The mean measurement of the bed, however, is from 8 to 10 inches. Along Youngs Branch, and along Willow Run also, the general features of the members are much the same as they are in Buckhorn Hollow.

Symmes Township.—The Ferriferous members appear above drainage level in only one locality in Symmes Township, which is on Buffalo Creek, in the vicinity of the Rehmer School, where the following was measured:

	Ft.	In.
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*	5	9
Coal blossom, *Clarion*	--	3

Washington Township.—Activity in the mining of the materials from the Ferriferous horizon has been nearly continuous in Washington

Township since the erection of Olive Furnace in 1833. At present the ore is not regularly mined, but the limestone is worked in a large way for road ballast and for furnace flux. The members extend entirely across the township, and with few exceptions have normal volume and quality. Along Olive Creek, east of Olive Furnace, the Ferriferous limestone has an average thickness of about 6 feet, while the ore is reported to measure about 8 inches. At Olive Station the following measurements were taken:

	Ft.	In.
Ore, *Ferriferous*	--	10
Limestone, *Ferriferous*	7	--
Shale	--	2
Coal and partings, *Clarion*	5	4

In the first hollow west of the furnace stack the limestone measured 6 feet and the ore 4 inches, while on Brushy Fork the ore in places is replaced by a thick sandstone, but the limestone is present in force. On the main ridge north of this both members are rather steady, but the limestone is often flinty in character, and the ore replaced in restricted areas by the thick overlying sandstone. On Brady Creek, near the Town House, on the Ironton Road in Section 23, the beds have the following volumes:

	Ft.	In.
Ore, *Ferriferous*	--	6
Limestone, *Ferriferous*	6	--
Shale	--	3
Coal and partings, *Clarion*	5	5

Other measurements taken west of this along Brady Creek show from 5 to 7 feet of limestone and from 1 to 10 inches of ore. In the central part of Section 16 the Bear Run Mining Company mines by drifting the Ferriferous limestone for flux stone at the Jackson furnaces, and the Clarion coal for the general market. Measurements taken at the mine follow:

	Ft.	In.
Ore, *Ferriferous*	--	2
Limestone, *Ferriferous*	8	--
Shale	--	2
Coal and partings, *Clarion*	6	8

Near the plant of the Portsmouth Refractories Company, in Section 10, the limestone measured 6 feet and the ore 6 inches. East of this, in Section 3, the measurements obtained follow:

	Ft.	In.
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*	7	3
Shale	--	3
Coal and partings, *Clarion*	3	9

In Irish Hollow and along the headwaters of Black Fork Creek the Ferriferous members are very steady, and the limestone is mined for road ballast and flux stone. This bed varies from 4 to 9 feet in thickness; while the ore usually measures from 2 to 10 inches. A section taken near the plant of the Cambria Clay Products Company is given below:

	Ft.	In.
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*	9	--
Shale	--	1
Coal and partings, *Clarion*	4	--

Economic Value of the Ferriferous Limestone

During the days of the charcoal furnaces the Ferriferous limestone was used for flux stone, but at present it is extensively used not only for this purpose, but for cement, road ballast, concrete, and agricultural lime. Its value has steadily increased, and will probably continue to do so in the future, for increased quantities are required each year, and other uses also arise. It is one of the most important beds found in Lawrence County.

The average thickness of the Ferriferous limestone shown by 56 sections is 6 feet 1 inch. In the southern part of the field the thickness seldom reaches 7 feet; while in the northern part it often measures from 8 to 9 feet. The specific gravity is 2.68, so that the yield per acre where the rock is 6 feet 1 inch thick and 60 per cent is obtained would be 13,316 net tons. The total quantity available in the county is large and amply sufficient to supply the needs for many years.

Because the limestone is extensively mined by drifting, its roof is a matter of importance. Small areas in the region have sandstone above the limestone for roof materials. Near the Ironton Portland Cement Company's plant, the sandstone lies close to the limestone. Another area, in which the relations are similar, is found from Lawrence Furnace north to Bartles and to Center Station, thence west to the Superior Cement Plant and also east from Lawrence Furnace to where the member passes below drainage on Cannons Creek. The sandstone also overlies the limestone from Olive Furnace west to the Lawrence County line, and also along the upper course of Brushy Fork. In the remainder of the region clay or shale forms the roof. The clays are soft and tender and contain many pressure cleavage planes, consequently mining under them is both expensive and dangerous. The shales form a better roof except where tender and much jointed. Where either clay or shale forms the roof, it is much safer and more economical to leave up part of the limestone.

The cost of mining depends largely on the structure and relation of the strata on the equipment and on the tonnage produced. Where part of the limestone is left for the roof, and the production is about 150 tons per day, John M. Hanes reports the cost for drilling, shooting, loading, and hauling to be about 30 cents per ton, but in large well-equipped mines this cost would be reduced somewhat. Where the limestone is mined by stripping, the cost depends on the thickness of the cover that must be removed and on the expense of shooting, loading, and hauling, all of which Mr. Hanes reports to average about 25 cents per ton.

The Ferriferous limestone is much the same in character throughout the whole extent of the deposit with the exception that in some places flinty layers are found in the upper part. Near the head of Brushy Fork 3 feet of the upper part is cherty or flinty, and this condition was noted at other places. Generally these flint deposits are local in extent and are more abundant along the outcrop than under heavy cover. The limestone is dense and hard, but rather brittle. The color varies from a light to a dark gray. The deposit is massive, but an irregular bedding plane is noticed about 1 foot 6 inches from the top. The quality of the stone is shown by the following analyses collected from various sources.

Analysis reported by Hanging Rock Iron Company, sample from their mine near Royer Station:

Silica, SiO_2	.48	Silica, SiO_2	.48
Iron, Fe	.98	Alumina, Al_2O_3	1.04
Alumina, Al_2O_3	1.04	Ferric oxide, Fe_2O_3	1.20
Lime, CaO	53.92	Iron sulphide, FeS_2	.30
Magnesia, MgO	.40	Calcium phosphate, $Ca_3P_2O_8$	.24
Sulphur, S	.164	Calcium Carbonate, $CaCO_3$	96.02
Phosphorus, P	.050	Magnesium Carbonate, $MgCO_3$	.84
			100.12

The following analyses of the limestone were furnished by the Lawrence Furnace Company. Analyst, Marion Melvin.

	Sample No. 1	Sample No. 2
Silica, SiO_2	.76	1.16
Alumina, Al_2O_3 Iron oxide, Fe_2O_3	1.92	2.24
Calcium carbonate, $CaCO_3$	93.01	92.80
Magnesium carbonate, $MgCO_3$	.69	.49
Water, not determined.		

An analysis of a sample from the river hills near Coalgrove is as follows. Analyst, W. M. Barnett.

Silica, SiO_2	.94	Silica, SiO_2	.94
Alumina, Al_2O_3	1.41	Alumina, Al_2O_3	1.41
Iron, Fe	7.40	Iron oxide, Fe_2O_3	10.57
Lime, CaO	46.15	Calcium phosphate, $Ca_3P_2O_8$	.64
Magnesia, MgO	.81	Calcium carbonate, $CaCO_3$	81.79
Phosphorus, P	.127	Magnesium carbonate, $MgCO_3$	1.70
Water, not determined.			

The high iron shown by this analysis is due to the Ferriferous ore being "frozen", as miners say, to the limestone, that is, there is no well defined parting between the ore and the limestone. This transition stage may be a foot or more thick.

The analysis of a sample from the E. B. Willard mine near Bartles Station is reported as follows. Analyst, W. M. Barnett.

Silica, SiO_2	1.20	Silica, SiO_2	1.20
Alumina, Al_2O_3	2.98	Alumina, Al_2O_3	2.98
Iron, Fe	.90	Iron oxide, Fe_2O_3	1.29
Lime, CaO	52.25	Calcium phosphate, $Ca_3P_2O_8$	.37
Magnesia, MgO	.68	Calcium carbonate, $CaCO_3$	92.95
Phosphorus, P	.075	Magnesium carbonate, $MgCO_3$	1.43
			100.22

The analysis reported by The Ginn Company of the limestone at its quarry south of Vesuvius Station is given below:

Silica, SiO_2	3.19
Alumina, Al_2O_3 Iron oxide, Fe_2O_3	1.62
Calcium carbonate, $CaCO_3$	92.58
Magnesium carbonate, $MgCO_3$	2.39
Total	99.78

The analysis of the limestone at Etna Furnace reported by Mr. Wm. H. McGugin is as follows:

Silica, SiO_2	1.20
Alumina, Al_2O_3 Iron oxide, Fe_2O_3	2.70
Calcium phosphate, $Ca_3P_2O_8$	.26
Calcium carbonate, $CaCO_3$	95.65
Magnesium carbonate, $MgCO_3$	.19
	100.00

The analysis which is reported by the Belfont Iron Works Company, and which is representative of the stone from Lawrence County used by them for furnace flux, is given below.

Silica, SiO_2	1.50
Alumina, Al_2O_3 Iron oxide, Fe_2O_3	1.37
Calcium carbonate, $CaCO_3$	95.72
Magnesium carbonate, $MgCO_3$	1.30
Phosphorus, P	.0695
Sulphur, S	.188

The analysis reported by the Globe Iron Company of Jackson, Ohio, of the limestone at the mines of the Bear Run Mining Company near Eifort is as follows:

Silica, SiO_2	1.16
Alumina, Al_2O_3	2.20
Lime, CaO	52.50
Magnesia, MgO	1.17
Calcium carbonate, $CaCO_3$	93.71
Magnesium carbonate, $MgCO_3$	2.43

The Superior Portland Cement Company reports the following analysis as representative of the limestone used by them in the manufacture of cement:

Silica, SiO_2	.45
Alumina, Al_2O_3	.56
Ferric oxide, Fe_2O_3	2.02
Lime, CaO	52.64
Magnesia, MgO	.43
Ignition loss	43.40

Analyses of the limestone from the mines at Bartles Station furnished by Mr. E. B. Willard are as follows:

	No. 1	No. 2
Silica, SiO_2	.30	.60
Alumina, Al_2O_3	.81	1.66
Iron oxide, Fe_2O_3	1.89	----
Lime, CaO	53.82	50.55
Magnesia, MgO	.03	----
Phosphorus, P	----	.065
Sulphur, S	----	.237
Calcium carbonate, $CaCO_3$	96.11	90.27
Magnesium carbonate, $MgCO_3$	.63	----

Additional Analyses of Ferriferous Limestone Collected from Various Sources

	Siliceous matter. SiO_2	Alumina. Al_2O_3	Ferric oxide Fe_2O_3	Calcium carbonate. $CaCO_3$	Magnesium carbonate. $MgCO_3$	Total.
Sample No. 1	.98	2.15		94.65	1.84	96.92
" " 2	.41	.86	.78	93.28	4.66	99.99
" " 3	.52	.80	----	94.19	4.49	100.00
" " 4	3.30	6.20		88.50	.75	98.75
" " 5	.76	1.50		96.83	.84	99.93
" " 6	1.10	3.20	5.25	88.70	1.60	99.85
" " 7	.26	.50	1.30	96.83	1.00	99.89
" " 8	1.00	1.00	2.00	94.30	1.53	99.83
" " 9	1.67	1.36		95.40	1.38	99.81
" " 10	1.52	1.86	.70	95.40	.53	100.01
" " 11	.74	.24	1.30	97.35	.33	99.96
" " 12	3.26	.90	1.30	94.16	.85	100.47

Sample No. 1.—California Hollow, Upper Township, Hecla Iron Co., Geol. Surv. of Ohio, Fourth Ser., Bull. 4-5, p. 86.

Sample No. 2—Burke's Mine, Elizabeth Township, Geol. Surv. Ohio, Fourth Ser., Bull. 4-5, p. 86.

Sample No. 3—Riley's Mine, Elizabeth Township, Geol. Surv. Ohio, Fourth Ser., Bull. 4-5, p. 86.

Sample No. 4—Burgess tract, Hanging Rock Iron Company, average of 10 analyses, Fourth Ser., Bull. 4-5, p. 86.

Sample No. 5. Bradshaw entry, Hanging Rock Iron Company, Fourth Ser., Bull. 4-5, p 86.

Sample No. 6. School House entry, Hanging Rock Iron Company, Fourth Ser., Bull. 4-5, p. 86.

Sample No. 7. Peters Cave Hollow, Mines of E. B. Willard, Fourth Ser., Bull. 4-5, p. 86.

Sample No. 8. Pine Grove Furnace, Hanging Rock Iron Company, Fourth Ser., Bull. 4-5, p. 86.

Sample No. 9. H. Campbell and Son, Analysis by Lord, Fourth Ser., Bull. 4-5, p. 86.

Sample No. 10. Olive Furnace, 6 feet, 9 inches, no flint. Fourth Ser., Bull. 4-5, p. 86.

Sample No. 11. Burke's Mine, Bartles Station, 7 feet, 6 inches. Fourth Ser., Bull. 4-5, p. 86.

Sample No. 12. Willard's Mine, Steece P. O., 6 feet, 6 inches. Fourth Ser., Bull. 4-5, p. 86.

Analyses of samples taken from three carloads of limestone from the Morgan and Horton quarry near Eifort, Scioto County, which is close to the Lawrence County line, show the variation in the sulphur content. Analyses furnished by the Buckeye Steel Casting Company, Columbus, Ohio. Analyst, Downs Schaaf.

	Sample No. 1	Sample No. 2	Sample No. 3
Silica, SiO_2	1.20	1.20	1.40
Alumina, Al_2O_3 Ferric oxide, Fe_2O_3	1.04	1.00	1.10
Calcium carbonate, $CaCO_3$	94.43	95.23	94.13
Magnesium carbonate, $MgCO_3$	3.33	2.57	3.37
Sulphur, S	.450	.167	.257

Phosphorus, P, not determined.

An average composition of the Ferriferous limestone where unweathered in Lawrence County is about as follows:

Silica, SiO_2	1.29	Silica, SiO_2	1.29
Alumina, Al_2O_3	1.44	Alumina, Al_2O_3	1.44
Iron, Fe	.84	Ferrous carbonate, $FeCO_3$	1.30
Lime, CaO	52.57	Ferric sulphide, FeS_2	.45
Magnesia, MgO	.78	Calcium carbonate, $CaCO_3$	93.42
Phosphorus, P	.093	Magnesium carbonate, $MgCO_3$	1.64
Sulphur, S	.24	Calcium phosphate, $Ca_3P_2O_8$	.46
			100.00

The normal calcium carbonate present in the limestone averages high. In some localities, however, the upper part of the stratum is flint, or it is flinty in character, and in a few places the entire deposit contains considerable siliceous material. Excluding these, the average for the deposit is about 93 per cent. Normally the magnesium carbonate present is low. In a few localities it runs to about 5 per cent; while in others it is below 1 per cent and on the average it is nearly 1.5 per cent. In this respect it is superior to the Trenton limestone in the Lehigh Valley cement district of eastern Pennsylvania. The silica or siliceous matter present, when the entire stratum is considered, varies between wide limits owing to the flinty or siliceous nature of the rock in certain regions. From what has been said the silica content will vary both with the locality, and with the part of the deposit considered. The range is from less than 1 to as much as 50 per cent silica.

The limestone also shows a wide variation in the iron content, which is due principally to the weathering of the overlying Ferriferous ore. This ore was deposited as a blue ferrous carbonate in contact with the limestone, or with only a thin shale intervening. Percolating waters holding oxygen and carbon dioxide in solution attack the ferrous carbonate and change a part of it to ferric hydrate, which remains as an insoluble compound, but as ferrous carbonate is somewhat soluble they carry a small quantity of the Ferrous mineral down into the limestone below, where, with the aid of oxygen, ferrous carbonate reacts with the calcium carbonate, precipitating ferric hydrate and producing soluble calcium carbonate, which is thus carried away. This impregnation of the limestone by ferric oxide is seen only along the outcrop or under shallow cover where these agencies are active. Often the joints between the blocks of limestone are filled with this ore, and along the outcrop in some localities ferruginous clay masses occur below the deposit.

The alumina in the Ferriferous limestone varies from about .5 to 3 per cent, with an average of about 1.5 per cent. For the most part it is combined with silica and water in the form of kaolinite, but from some of the analyses, if correct, it is also a component of other minerals in which the content of alumina is greater. Most of the analyses given are really incomplete, as they fail to show the sulphur, phosphorus, and manganese. Sulphur and phosphorus are invariably present in appreciable quantities, and are important when the use of the stone is considered for metallurgical purposes. Most of the sulphur present in the limestone is found in the form of iron disulphide or pyrite, which can be detected usually by the eye. Occasionally small crystals of lead sulphide or galena are found. The amount of sulphur may run as high as .5 per cent. The phosphorus, which is normally from .05 to .30 per cent, and averages about .10 per cent, occurs principally in the form of calcium phosphate. Manganese is invariably present in small amounts, ordinarily in only a few hundredths of a per cent.

Cement.—This limestone is well suited for the manufacture of Portland cement, and compares favorably with the standard cement limestone used in the United States. Magnesia, sulphur, and alkalies are detrimental, and iron oxide, if high, is looked upon with disfavor. In composition it varies between the following limits:[1]

Ingredients.	Minimum Per cent.	Maximum Per cent.	Average of 10 standard American Portland cements. Per cent.
Silica, SiO_2	19.	26.	21.76
Alumina, Al_2O_3	4.	11.	7.51
Ferric oxide, Fe_2O_3	2.	5.	3.34
Lime, CaO	58.	67.	62.61
Magnesia, MgO	0	5.	1.94
Sulphuric acid, SO_3	0	2.5	1.19
Alkalies, K_2O, Na_2O	0	3.	not determined.

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[1] Geol. Survey of Ohio, Fourth Ser., Bull. No. 3, pp. 197-198.

The silica and alumina in the Ferriferous limestone are in such proportions that shale or clay is required to bring them to the proper ratio for cement. These are easily supplied, as shale or clay suitable for this purpose is found either with or close to the limestone deposit. The Superior Portland Cement Company uses either the shale that lies above the limestone, or the clay and shale that are found below it. In both cases the clay or shale and limestone are taken from the same entry. The York Portland Cement Company, now dismantled, of Portsmouth, Ohio, obtained its supply from the shale above the limestone. The magnesia is well below the limit demanded for this ingredient, as it seldom exceeds one per cent in the finished cement. The sulphur in the limestone, while objectionable, is not serious, although the quantities are from .1 to .5 per cent, as part of this passes off as gas during the clinkering. The high iron oxide in the limestone is looked upon with disfavor. In the cement the quantity usually demanded by the trade is not in excess of 5 per cent. The iron oxide in the limestone under heavy cover is low, but under thin cover or along the outcrop it may run to several per cent. This component is usually high in the shales, and additional iron oxide is introduced where coal is the fuel used in clinkering. The cement made at present from these materials is classed as high iron cement, but has a good reputation for quality, and is used by the United States Government for locks, dams, and public buildings. The iron oxide darkens the color of the cement, which is objectionable where light colored work is desired.

The Ferriferous limestone is used by the Superior Portland Cement Company in the manufacture of its product. A description of the plant furnished by its superintendent, J. B. John, follows:

> The limestone is mined with Sullivan and Goodman mining machinery by undercutting the same as for coal. It is drilled with a Temple-Ingersoll drill. The limestone is gathered with a 5-ton electric locomotive and is taken to a tipple by a Goodman 12-ton electric locomotive.
>
> The shale we use is the cuttings from under the limestone, which is also taken to the tipple by electric locomotives. The limestone is dumped by automatic cross-over dumps into a No. 9 crusher, then passes through 2 No. 5's. The shale is run through a 9-foot dry pan and is taken to the mill on a conveyor belt; the limestone is treated likewise. The shale and limestone are then run through 60-foot dryers. After being thoroughly dried both are weighed and put through kominuters or ball mills, then the mixture goes to the tube mills where raw material is ground so that 95 per cent will pass through the 100-mesh sieve. We have 3 kominuters and 5 tube mills in the raw department.
>
> The ingredients are then taken to the kiln room where we have 4 kilns, 7½x125 feet long, in which they are burned to a clinker with coal previously pulverized in Fuller mills. The clinker is then elevated to Mosser stationary coolers from which after cooling it is carried on a conveyor belt to the finishing department where it is ground. The preliminary grinding in the clinker mill is done with 2 Mosser crushers and 1 duplex Sturtevant, 6 Griffin mills, and 3 tube mills. After being ground in the finishing department it is carried to the stock house where it is stored in bins. The packing is done with 3 Bates valve bag machines.

The analysis of Superior cement is as follows:

Silica, SiO_2	22.5
Alumina, Al_2O_3	7.0
Iron oxide, Fe_2O_3	4.5
Lime, CaO	63.0
Sulphur trioxide, SO_3	1.40
Magnesia, MgO	.85
Total	99.25

Flux.—For fluxing purposes the value of a limestone depends on the available bases present, and on the freedom of the stone from detrimental impurities. For blast furnace fluxes the active bases are lime, magnesia, and part of the manganese oxide, which in this limestone is usually low; hence it will not be considered further. The iron compounds are reduced, and the metal in them goes into the pig iron. The phosphorus, which also goes to the pig iron, if high, is detrimental in making a product for Bessemer steel. Sulphur is detrimental, as it decreases the available lime, and also saturates the slag, thus limiting the quantity of this element that can be taken from the molten iron in the furnace. Silica and alumina decrease the available lime, as they must be fluxed to form a slag. Taking the limestone of about an average composition, the results will be as follows:

Silica, SiO_2	1.29
Alumina, Al_2O_3	1.44
Iron, Fe	.84
Lime, CaO	52.57
Magnesia, MgO	.78
Phosphorus, P	.093
Sulphur, S	.24

To slag		*Fluxes*		*To iron*	
Silica, SiO_2	1.29	Lime, CaO	52.57	Iron, Fe	.84
Alumina, Al_2O_3	1.44	Magnesia, MgO	.78	Phosphorus, P	.093
	2.73		53.35		.933
Lime, CaO Magnesia, MgO	2.73	Lime, CaO	2.73		
		Lime, CaO to CaS	.30		
Calcium sulphide, CaS	.54		3.03		
Slag produced	6.00	Available fluxes	50.32		

This compares favorably with other standard flux limestones used in Ohio, as shown below:

Limestone used for flux from Kelleys Island:[1]

Silica, SiO_2	1.81	Silica, SiO_2	1.81
Alumina, Al_2O_3 Iron oxide, Fe_2O_3	.75	Alumina, Al_2O_3	.35
		Iron, Fe	.21
Calcium carbonate, $CaCO_3$	87.50	Lime, CaO	49.00
Magnesium carbonate, $MgCO_3$	9.75	Magnesia, MgO	4.64

Slag produced, 4.32. Available fluxes, 51.48. Iron, 0.21.

In the above the iron oxide is assumed to be .30 per cent.

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[1] Geol. Surv. Ohio, Fourth Ser., Bull. No. 4-5, p. 62.

Limestone used for flux from Columbus:

Silica, SiO_2	2.30	Silica, SiO_2	2.30
Alumina, Al_2O_3	.70	Alumina, Al_2O_3	.70
Iron oxide, Fe_2O_3	.52	Iron, Fe	.36
Calcium carbonate, $CaCO_3$	90.16	Lime, CaO	50.49
Magnesium carbonate, $MgCO_3$	5.90	Magnesia, MgO	2.81
Phosphorus, P	.015	Phosphorus, P	.015
Water, H_2O	.12		

Slag produced, 6.00. Available fluxes, 50.30. Iron, 0.38.

The average analysis of Piqua stone which is used mainly for the magnesia and phosphorus contents is reported by the Belfont Iron Works Company as follows:

	No. 1	No. 2
Silica, SiO_2	.24	.36
Alumina, Al_2O_3 Iron oxide, Fe_2O_3	.37	.60
Calcium carbonate, $CaCO_3$	82.88	78.20
Magnesium carbonate, $MgCO_3$	15.00	17.76
Phosphorus, P	.0034	.0042
Sulphur, S	.0426	.047

Averaging the two samples and considering the iron oxide to be one-half the iron oxide and alumina content, the results are as follows:

Slag produced, 1.18. Available fluxes, 52.28. Iron, 0.1718.

Mr. Karl Steinbacher, superintendent of the Belfont Iron Works Company, reports:

> The company used, during the time in blast in 1912, 19,000 tons of Piqua stone and 4,600 tons native stone. Also they are using Piqua stone exclusively at present on account of the high phosphorus in the native stone.

Mr. W. M. Jeffreys, superintendent of the Hanging Rock Iron Company, reports as follows:

> The limestone is of a very good grade for use as flux in a blast furnace. This company and one in Ironton, Ohio, use the limestone in their furnaces and obtain excellent results. This limestone is quarried both in the open and under ground. The stone from the open bed is obtained by stripping the upper surface, and that under ground by the usual method of drift mining. Our experience in the mining of this limestone has taught us that a much better grade of furnace flux is obtained from the under ground quarry.

Mr. John E. Jones, general manager of the Globe Iron Company, Jackson, Ohio, reports:

> This company, in connection with the Star Furnace Company, has been opening up limestone territory in Lawrence County, abutting Jackson and Scioto counties, and has installed operations for the mining and handling of same. Approximately the two furnaces will use 50,000 tons limestone per year while in blast.

Road Building.—The dense tough nature of the stone makes it an excellent material for road building. In the construction of the macadam roads, in this and the adjoining counties to the west, it is largely used, and has proved quite satisfactory. Mr. Charles Hutchinson, Commissioner of Lawrence County, regards the Ferriferous limestone superior to either the Cambridge or Brush Creek for road building. Mr. A. S. Rea, of the State Highway Department, states that tests made on the Columbus and Delaware limestones, which are used extensively for road building, and also tests on two samples of Ferriferous limestone from Lawrence County, show that the Ferriferous limestone is of good character for this purpose, and compares favorably with the two other limestones named.

Since most of the firms or private parties, operating mines or quarries, are producing both furnace flux and road material, they will be listed together. On the John Peters property, near Coalgrove, a small quantity of stone, mined by stripping, is quarried for furnace flux and road material. The Hanging Rock Iron Company operates mines near Royer Station for flux stone for its two furnaces. Lawrence Furnace, in Elizabeth Township, is using the Ferriferous limestone mainly for flux, which is obtained principally from two workings, that of E. L. Lambert, and that of Edward Kelley. Mr. Lambert mines by stripping, for the roof is shale and clay. At the mine of Mr. Kelley, less than one mile distant, the roof is sandstone; hence the limestone is worked by drifting. The total output amounts to about 20,000 tons per year.

E. B. Willard has well equipped mines near Bartles Station, in Elizabeth Township. The method of mining is by drifting, as the roof is a massive sandstone. About 45 men are employed, and approximately 60,000 tons per year are shipped for furnace flux, and about 2,000 tons, on the average, for road building.

The mines of Michael Riley are situated near Center Station, on the Detroit, Toledo & Ironton Railroad. The roof is a massive sandstone, therefore the mining is done by drifting. The mine is equipped with air compressed drills, and the limestone is loosened with dynamite. The long wall system is used. On an average 20 men are employed, and the quantity of stone mined per year is about 25,000 tons. The Ironton furnaces are the principal market. Mr. W. R. Maxey ships some limestone from his workings, which are located on the Detroit, Toledo & Ironton Railroad, about one mile west of Lawrence Furnace. The deposit, which lies well up on the hills, has shale and clay for roof materials; hence it is mined by benching. At present he is installing an 80 h. p. engine and an 18-inch jaw crusher. Approximately 5,000 tons of stone per year are shipped for road ballast, furnace flux, and concrete work. Small amounts of stone are shipped on the Cincinnati, Hamilton & Dayton Railway from the Hall mines, near Jep Station, in Decatur Township, and from the McGugin mines, near Olive Station.

The Bear Run Mining Company, near Eifort, in Washington Township, mine the supply of stone used for furnace flux by the Globe and Star furnaces of Jackson, Ohio. A switch 1¼ miles long runs from the Baltimore & Ohio Southwestern Railroad to the mines. Both coal and stone are shipped. The tipple is provided with four tracks for railroad cars, so that the different grades of coal and stone can be loaded at the same time. The tram road from the tipple to the mines is 1,200 feet long. The grade on the tram is sufficient to allow the cars to run from the mines to the tipple by gravity. Mule power is used to haul the cars to the mines. Compressed air drills are used in mining the stone, which is crushed by a No. 5 Austin spindle crusher, with a capacity of 40 tons per hour. The power for the crusher is produced by a 45 h. p. engine, made by Houston-Stanwood & Gamble Company, Cincinnati, Ohio. The compressor, which is also provided with a 45 h. p. engine, is made by the Bury Compressor Company, Erie, Pa. The steam is supplied by a 75 h. p. boiler, made by the Gem City Boiler Works, Dayton, Ohio, The number of men employed for mining both coal and stone is from 100 to 120, and the output of stone is about 50,000 tons per year.

The Cambria Clay Products Company also mines the Ferriferous limestone with the Clarion coal. S. P. Reitz reports as follows:

> We are mining 4 feet of the Clarion coal which is overlaid with 7 feet of limestone. After the coal is mined the limestone is drilled and shot down to a height of 5 to 6 feet, leaving the balance of the stone for a roof. The limestone is used for blast furnace and macadam purposes.

For open hearth furnace flux magnesia is not desired; hence the fluxing value of a limestone is based on the available lime only. Sulphur, if high, is objectionable. The steel producers require a slag that will take up sulphur from the molten metal; consequently, as the quantity of this element that a slag can hold in solution is limited, all sulphur introduced with the flux lessens equivalently the quantity of this component taken from the metal. Silica, if high, is also undesirable, as it tends to throw the sulphur out of solution in the slag, or as it decreases the solubility. The quantity of sulphur eliminated from the metal depends to a considerable extent on the basicity of the slag. The quantity of phosphorus contained in the limestone, unless high, is unimportant. It is in fact beneficial rather than detrimental.

Lime.—For hydrated lime the high magnesian limestones are preferred. The Ferriferous limestone makes a hot, violent lime, which excludes its use for many purposes. There is a good field for hydrated lime for fertilizers in southern Ohio for much of the land, especially that where the soil has been derived largely from shales and sandstones of the Mississippian, and of the lower part of the Pennsylvanian series, is deficient in this ingredient. Plant life requires both lime and magnesia, but by far more of the former. Lime made from this stone is well suited for this purpose, in fact it is much better than the dolomitic lime found largely on the market. There are no regular lime burning plants in the county, but small quantities are occasionally burned by the farmers. They make a pile on the ground of layers of stone and coal or wood, which is then fired and allowed to burn until the fuel is consumed. The calcination is imperfect, as the outer layers of stone are but little affected, and the larger lumps have unburned cores. Some farmers prefer the raw limestone, ground very fine, to the hydrated lime, as it causes less trouble in drilling, and as its effects are more lasting.

Concrete.—The stone is well suited for concrete work. It is dense and firm, and it breaks into angular pieces with sharp edges and corners. It is not classed as a good building stone, for it does not cut well, but for foundation work it can be used to good advantage.

In conclusion, the Ferriferous limestone is well adapted for the manufacture of Portland cement, for blast furnace flux when basic, malleable, or foundry iron is made, for concrete work, for road building, and for fertilizers.

Economic Value of the Ferriferous Ore

During the days of the charcoal furnaces the Ferriferous ore was the most important bed in Lawrence County, but owing to the influence of the Lake ores, and to the increased demands of the modern furnaces, it has gradually decreased in influence from that time, so that at present the member is an asset of small value. While the quality of the Ferriferous ore is inferior to the high-grade Lake ores, and while the stratum is thin and variable, yet its relation to the furnaces in this region is such that the bed is worthy of careful consideration. The ore lies directly above the Ferriferous limestone, which association is also of interest.

The Ferriferous ore is a persistent deposit, but varies considerably in thickness in different localities. In the shale or clay above this deposit one or more layers of kidney ore occur in parts of the region. These are of the same general origin as the ore below, and consequently they are given as a part of the Ferriferous ore deposit. The section near Lawrence Furnace shows three rows of kidney ore which E. L. Lambert, who has had a very extended experience in the region, says will average 10 inches in thickness. At the mine of W. R. Maxey, west of Lawrence Furnace, two rows of these kidneys are found, but at the limestone mine of the Hanging Rock Iron Company, near Royer Station, only one layer is present.

The Ferriferous ore was seen in 23 places in Lawrence County and the average thickness of the bed is 7 inches. On the whole, the bed is somewhat thicker than this, as some of the exposures noted were on the outcrop where the bed was thin and was worked but little during the days of the charcoal furnaces. Where the ore was heavy it was benched to deep cover, so that at present it is seldom seen under favorable conditions. The average thickness of the ore is reported by various parties who formerly mined it to be about 12 inches. The average thickness given in the chapter on Lawrence County in the Report of Progress for 1870 for 15 sections is 10½ inches, which is probably near the true thickness. In places the ore is very thin, only an inch or two being present, while in a few localities it expands to 3 or 4 feet over small areas.

The ore is of swamp origin. It was deposited in quiet waters heavily charged with carbon dioxide, which precipitated the soluble ferrous salts brought in as ferrous carbonate. Under heavy cover the ore still exists as the carbonate, but along the outcrop or under light cover it has been oxidized more or less to ferric hydrates. The specific gravity of the limonite ore will average about 2.9; while that of the carbonate will run close to 3.5. Considering the ore 10 inches thick and 60 per cent available, the yield per acre will be 1,974 net tons for the limonite and 2,382 net tons for the carbonate. For the charcoal furnaces the ore was mined mainly along the outcrop by stripping. Some small entries were worked, but these extended only short distances under cover. Carbonate ores were difficult to smelt in the short stack charcoal furnaces, so that only the oxidized or limonite ores were desired. Consequently the main body of ore is scarcely touched as the deposit was followed only along the outcrop.

This deposit is generally too thin to be worked for the ore alone with any economy. Too much material must be removed for entry ways in order to get sufficient height. Ordinarily the roof is shale or clay, either of which is hard to hold. Where the deposit will average 15 inches or more in thickness, and where the roof is of good quality, it may be mined advantageously. If the associated materials have a value, then the ore may be mined with these. The ore and limestone are worked together in a few places. In some cases the clay above is of excellent quality and it may be mined with the ore At the present price of Lake ores, this deposit can be mined only in a secondary way, except in local areas where it is well above the normal thickness.

The quality of the Ferriferous ore varies between rather wide limits, yet the average composition compares favorably with that of the low grade Lake ores. The analyses given on Table II are instructive.

These analyses show the general quality of the ore. It is non-bessemer and best suited for foundry, but it can be used to good advantage in making either basic or malleable iron.[1]

Ore Comparisons.—In the comparison of the value of the Ferriferous or native and the Lake ores, the following items are used:[2]

Amount of ore smelted per day, 540 tons.

Ratio by volume of $\frac{CO}{CO_2}$ = 1.8 which is obtained with good practice.

Slag ratio $\frac{\text{bases}}{\text{acids}} = 1$.

Pocahontas coke used for smelting and a standard limestone for flux.

The figures for value of coke and stone delivered at Ironton, and for the over and above cost used, are these supplied by Col. H. A. Marting.

Over and above cost per ton 2,240 lbs. of ore smelted	$1.00
Coke, per ton of 2,000 lbs	2.85
Stone, per ton, 2,240 lbs	.85
Freight per ton ore, 2,240 lbs., from Lake	.90

The Hanging Rock Iron Company reports the following costs:

Cost of limestone per gross ton, 2,240 lbs., at furnace	.85
Average cost of coke per net ton, 2,000 lbs., at furnace	3.05
Freight on Lake ore per gross ton, 2,240 lbs., at furnace	.90
Over and above cost per ton ore, 2,240 lbs	1.0936
Cost of limestone ore per gross ton, 2,240 lbs., at furnace	1.92
Price of Hanna No. 1 ore used in comparison quoted by M. A. Hanna & Co., for season of 1913, delivered at Ironton, per ton	$4.04

Prices of Negaunee and Clinton silica ores quoted by the Cleveland-Cliffs Iron Company, delivered at Lower Lake ports are $3.57 per ton for the former and $2.22 for the latter.

Cost of Negaunee ore at Ironton would be $4.47 per ton.

Cost of Clinton silica ore at Ironton would be $3.12 per ton.

The price of Adriatic ore quoted by Pickands, Mather & Co., delivered to Lower Lake ports is $3.28, which at Ironton, Ohio, would be $4.18 per ton.

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[1] See Table II.

[2] See Table III facing page 352.

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It has been the common practice in southern Ohio not only to calcine the carbonate ores, but also the limonite or hydrate types. Where the ore is charged raw into the furnace the heat units used are as follows:

$Fe_2O_3\,3H_2O + (214 \times 4 = 856$ calories) $= Fe_2O_3 + 3H_2O$.
$3H_2O + (54 \times 592 = 31964$ calories) $= H_2O$ as gas.
$54 \times 200 \times .457 = 4936$ calories) = specific heat carried out by gases at [200° C.

Total = 37756 calories.

This is $\frac{37756}{214} = 176$ calories per unit of ore.

1 unit carbon gives 2,430 calories.

The gases produced in combustion carry out at 200° C.,

$$\frac{7}{3}\text{ units CO} = \frac{7}{3} \times 200 \times .3084 = 144 \text{ calories.}$$

$$\frac{307.6}{69.3}\text{ units } N_2 = \frac{307.6}{69.3} \times 200 \times .2488 = \frac{217}{361} \text{ calories.}$$

So from combustion of 1 unit carbon the available heat units are 2430—361 calories = 2069 calories. This means if the ore is charged raw an addition of $\frac{176}{2069}$ or .085 units of carbon are required.

Considering coke 90 per cent carbon, the requirement for roasting 2,000 pounds of ore, radiation losses neglected, is 189 pounds.

Where calcined in kilns with carbon for fuel, and if burned with perfect economy, the results are as follows:

Total requirement for expulsion of water same as before, 37,756 calories or 176 calories per unit of ore.

1 unit carbon gives 8,100 calories.

The gases produced in combustion carry out at 200° C.,

$$\frac{11}{3}\text{ units } CO_2 = \frac{11}{3} \times 200 \times .414 = 304 \text{ calories.}$$

$$\frac{615.2}{69.3}\text{ units } N_2 = \frac{615.2}{69.3} \times 200 \times .2448 = \frac{434}{738} \text{ calories.}$$

Available heat then is 8100—738 calories = 7362 calories. The fuel requirement is $\frac{176}{7362}$ or .024 units carbon per unit ore.

Considering the fuel 90 per cent carbon, the requirement for roasting 2,000 pounds of ore is 53 pounds. Radiation losses are not considered in the above, and the loss of heat due to air excess is neglected. The difference in fuel between calcining in the furnace, and in special kilns, is thus only 136 pounds per ton of ore. This saving is far overbalanced in loss of material, labor, etc., during calcination.

The common practice with furnace operators at present is to carry an 8 per cent water burden. This means 8 per cent of the total weight of the stock is water. The main reason is to keep the top of the furnace cool, which holds the reduction zone in the proper position. The water carries out the heat from the top of the furnace, thus keeping down the temperature. It is not important whether this is the hydroscopic or combined water from the stock. When dry stock is charged this zone is too near the top, which results in abnormal working of the furnace. So raw ore should give better results than the calcined. W. M. Jeffreys, superintendent of The Hanging Rock Iron Company, reports:

The ore located on our property in Lawrence County is what we usually term limestone ore. It is found in two grades, the red and the gray. In former years this ore was calcined before using it in the furnace, but for the past year the Hanging Rock Iron Company has abandoned this method of treatment and is now using the ore in the natural state, and the results from same are excellent."

The calcined ore is less firmly bonded than the raw ore. It is fragile, consequently considerable ore is lost in the form of dust, owing to the extra handling involved in calcination. The cost of preparing the ore for roasting either in piles or kilns must be considered, and also the interest on the money invested. Considering the points both for and against calcination, the latter outweigh the former. The best economy is obtained by using the ore in the natural state.

LOWER KITTANNING COAL AND CLAY

The Lower Kittanning coal and clay are assets of vast importance to Lawrence County. The coal bed has furnished for many years the main supply of fuel for domestic and factory uses in this county, and has afforded a good revenue from outside sources. The thick deposits of clay and shale on the Lower Kittanning horizon have scarcely been touched, although in Washington Township they are utilized for fire brick, building brick, and sewer pipe. Regarding these deposits Dr. Edward Orton says:

> Under this head we came to the great clay horizon of the State. Its importance far outweighs that of any other clay seam of our scale. Indeed, it is probably equal in value to all other sources of clay in the Coal Measures combined. * * * * It belongs between the Ferriferous limestone and the Lower Kittanning coal. Often it fills the entire interval between these well-known beds. In some sections, however, where the interval is usually expanded, a sandstone occurs and the clay and shale are consequently reduced to some extent thereby. * * * * * The Kittanning clay horizon proper is seen at its best where it enters the state from Pennsylvania, and where it leaves the state in its extension into Kentucky. In both of these localities of the Ohio Valley, viz., in Columbiana and Jefferson counties, on the one side, and on the other in Lawrence County, it shows large volume and excellent quality.[1]

Stratigraphy and Extent.

The Lower Kittanning coal on the average lies about 23 feet above the Ferriferous members and about 40 feet below the Middle Kittanning coal. The member is well developed in Upper, Hamilton, Elizabeth, Decatur, and Washington townships, where it has been worked for many years. The bed is also found above drainage in western Perry, Lawrence, and Aid townships; further it appears on Buffalo and Symmes creeks in the central part of Symmes Township. But little information was obtained in regard to these members under heavy cover, as only a few drill records are available. Owing to the worth of these beds they will be treated at some length and traced across the county. See Map V facing page 354.

Perry Township.—The Lower Kittanning coal and clay are found along the courses of the streams in the western part of Perry Township. The coal is mined at a number of places, but so far the clay has not been utilized. Along the Ohio River the Lower Kittanning

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[1] Geol. Survey of Ohio, Vol. VII, p. 65.

TABLE III

per ton 2240 pounds ore. Basis smelting 540 gross tons per day.[3]

Stone required for fluxing in pounds.		Cost of ore per ton 2240 pounds at Ironton, Ohio.	Cost of stone for flux at 85 cents per ton 2240 pounds.	Cost of coke for smelting at $3.05 per ton 2000 pounds.	Total cost of smelting one ton 2240 pounds ore.	Cost per ton 2268 pounds pig iron produced.	Comparative value of ores, using cost of Hanna No. 1 as basis on pig iron produced in smelting.
6.3	36	$1.92	$0.0543	$1.3357	$4.4036	$10.78	2.70
12.5	36	1.92	.1063	1.3941	4.5140	8.68	4.00
38.4	36	1.92	.3272	1.4368	4.7776	11.72	2.31
Exces			Credit				
.3	36	1.92	.0031	1.2530	4.2635	11.31	2.44
24.1	36	1.92	.2055	1.4395	4.6586	10.11	3.11
21.6	36	4.18	.1836	1.4832	6.9404	13.02	4.00
17.0	36	4.47	.1453	1.4685	7.1774	13.18	4.20
14.5	36	4.04	.1234	1.4279	6.6849	12.69	4.04
36.6	36	3.12	.3111	1.5352	6.0599	12.55	3.19

coal is present near the road level in the western part of the township, and passes below drainage on Lick Creek east of the village of Sheridan, where it is reported to be about 2 feet in thickness. Where the member is exposed west of this, it is somewhat unsteady as the coal is often partially or completely replaced by a thick sandstone that lies just above the coal horizon. At places, however, the coal has fair volume as shown by the following record obtained on the land of Julia McCowan, about one mile west of Sheridan:

		Ft.	In.
Sandstone, irregular		--	4
Coal	*Lower Kittanning*	2	1
Clay		1	--
Coal		1	--
Clay		2	--

On Little Ice Creek the Lower Kittanning members pass from view about one mile south of the village of Forestdale. The coal, although overlaid by a massive sandstone, usually has good volume. A section taken on the farm of Charles Holley is given below:

		Ft.	In.
Clay		1	--
Coal	*Lower Kittanning*	1	9
Clay		--	9
Coal		--	9
Clay		1	--

Near Forestdale this coal has been mined for local consumption for many years, and the territory is not yet exhausted. In a mine operated by Frank Brammer the average measurement of the bed is as follows:

		Ft.	In.
Sandstone		30	--
Coal	*Lower Kittanning*	2	6
Clay		1	--
Coal		--	9
Clay		2	--

The clay in this locality is seldom exposed for observation, as it lies close to drainage level, but it is reported to be as a rule from 3 to 5 feet in thickness. West of this, on the farm of Oscar Willis, the coal has much the same structure as it has at the Brammer mine. Where measured, the upper coal bench was 2 feet in thickness, the clay parting 1 foot 1 inch, and the lower coal bench 8 inches. Along the Dearing Road near the township line, this coal is regularly mined by drifting on the property of David Laymond, where the following measurements were obtained:

		Ft.	In.
Sandstone, massive		30	--
Disconformity.			
Coal	*Lower Kittanning*	1	8
Clay		1	--
Coal		--	8
Clay		2	--

Here the upper bench of coal varies from 1 foot 3 inches to 2 feet, while the lower bench of coal and the clay parting remain fairly constant. North of the Dearing road, on Little Ice Creek, this coal is also mined on the property of Charles Shaefer, and has much the same structure as shown in the above section. Along Ice Creek the Lower Kittanning members are above drainage eastward along the course of the stream to near the mouth of Turkey Fork. The coal is not so well represented here as it is on Little Ice Creek, and the clay is lacking somewhat in its normal volume and quality. Moreover, the parting between the two coal benches in places expands to several feet, as is shown by the following section, taken along the road about one mile south of the mouth of Turkey Fork:

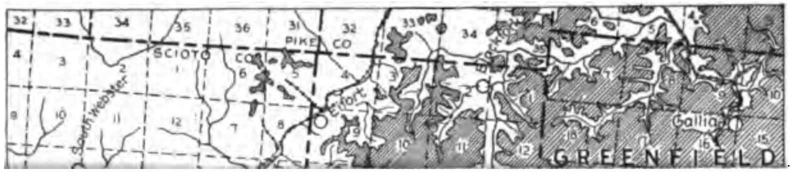
		Ft.	In.
Sandstone		20	--
Coal	*Lower Kittanning*	1	10
Clay and shale		8	--
Coal		--	10
Clay, plastic		1	10
Clay, siliceous		3	--

In the above section the Lower Kittanning clay member is divided by a thin carbonaceous shale into two divisions, which correlate with the two well developed clay beds found on this horizon in the central part of the county. Here the clays are thin and siliceous, but near the mouth of Sugar Creek they are much better developed, and often occupy most of the interval from the Ferriferous ore to the Lower Kittanning coal.

Upper Township.—The Lower Kittanning members are above drainage in all of Upper Township. The coal bed in this region has contributed a part of the factory and domestic fuel supply of Ironton for many years, and yet contains a large quantity of coal for future demands. The largest unworked fields are in the vicinity of Hecla Furnace. The stratum has excellent continuity throughout the township, but in some localities the bed is somewhat thin and impure. The volume of the clay deposits is usually large; while the quality is up to the standard for a plastic clay of coal formation origin. Near Coalgrove, on the John Peters property, a general section showing the character of the rocks in the Lower Kittanning interval was obtained, and is given below:

		Ft.	In.
Sandstone		10	--
Coal	*Lower Kittanning*	2	4
Clay		--	6
Coal		--	10
Clay, good		3	--
Sandstone		11	--
Shale		2	6
Ore layer, in shale		--	6
Clay, sandy		2	6

MAP V.



Here the upper bench of coal varies from 1 foot 3 inches to 2 feet, while the lower bench of coal and the clay parting remain fairly constant. North of the Dearing road, on Little Ice Creek, this coal is also mined on the property of Charles Shaefer, and has much the same structure as shown in the above section. Along Ice Creek the Lower Kittanning members are above drainage eastward along the course of the stream to near the mouth of Turkey Fork. The coal is not so well represented here as it is on Little Ice Creek, and the clay is lacking somewhat in its normal volume and quality. Moreover, the parting between the two coal benches in places expands to several feet, as is shown by the following section, taken along the road about one mile south of the mouth of Turkey Fork:

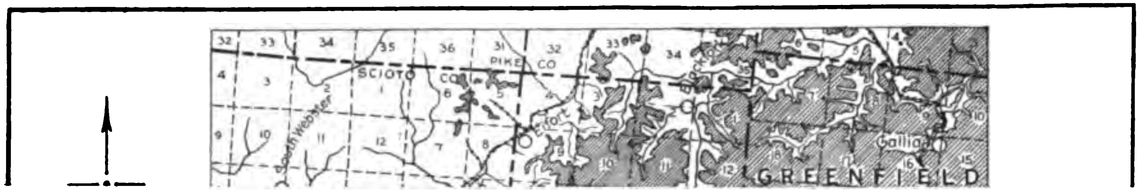
		Ft.	In.
Sandstone		20	--
Coal	*Lower Kittanning*	1	10
Clay and shale		8	--
Coal		--	10
Clay, plastic		1	10
Clay, siliceous		3	--

In the above section the Lower Kittanning clay member is divided by a thin carbonaceous shale into two divisions, which correlate with the two well developed clay beds found on this horizon in the central part of the county. Here the clays are thin and siliceous, but near the mouth of Sugar Creek they are much better developed, and often occupy most of the interval from the Ferriferous ore to the Lower Kittanning coal.

Upper Township.—The Lower Kittanning members are above drainage in all of Upper Township. The coal bed in this region has contributed a part of the factory and domestic fuel supply of Ironton for many years, and yet contains a large quantity of coal for future demands. The largest unworked fields are in the vicinity of Hecla Furnace. The stratum has excellent continuity throughout the township, but in some localities the bed is somewhat thin and impure. The volume of the clay deposits is usually large; while the quality is up to the standard for a plastic clay of coal formation origin. Near Coalgrove, on the John Peters property, a general section showing the character of the rocks in the Lower Kittanning interval was obtained, and is given below:

		Ft.	In.
Sandstone		10	--
Coal	*Lower Kittanning*	2	4
Clay		--	6
Coal		--	10
Clay, good		3	--
Sandstone		11	--
Shale		2	6
Ore layer, in shale		--	6
Clay, sandy		2	6

MAP V.



	Ft.	In.
Clay, good	6	--
Ore	--	6
Limestone, *Ferriferous*	5	--

East of this, along the river hills, the coal thins somewhat, and often becomes erratic in structure. A section obtained along the road in the extreme southeastern part of the township illustrates the thinning of the bed from its normal volume. The measurements follow:

		Ft.	In.
Sandstone, massive		25	--
Coal	*Lower Kittanning*	--	6
Coal, bony		--	1
Coal		--	11
Clay		--	8
Coal		--	7
Clay		3	--

North of Coalgrove this bed has been mined regularly by drifting, for a part of the local supply, and is reported to have approximately the same structure as was shown for the bed on the land of John Peters. At the plant of the Ironton Portland Cement Company the following measurements were obtained:

		Ft.	In.
Sandstone		20	--
Coal	*Lower Kittanning*	2	6
Clay		--	6
Coal		1	--
Clay		3	--

The upper bench of coal is reported to vary from 2 to 3 feet in thickness. The clay lying directly below the coal is generally thin and siliceous, but that lying at the base of the interval is stated by Albert Steece to vary from 3 to 12 feet, and to be of good quality, in fact, much better than the clay found above it. Along Sugar Creek, south of the Marion Road, in the northeastern part of the township, the clay is reported to have exceptional volume. Thousands of tons have been piled on the dumps in the mining of the Ferriferous ore. The coal in this locality is reported to be somewhat below normal, but quite persistent. In places in this locality nearly the whole interval from the ore to the coal is reported to be made up of clays which have excellent quality. Near where the Marion Road crosses Sugar Creek both the Lower and Middle Kittanning coals are mined in a small way. A record obtained here is given below:

		Ft.	In.
Shale		2	--
Coal	*Middle Kittanning*	1	7
Shale		--	1
Coal		1	7
Clay		2	--
Covered		10	--

		Ft.	In.
Sandstone		34	--
Shale		--	8
Coal	Lower Kittanning	1	11
Clay		--	7
Coal		1	--
Clay		2	--

The field of Lower Kittanning coal, near Hecla Furnace, has not been worked, except in a small way for local needs. A section, taken near the furnace, follows:

		Ft.	In.
Shale		2	--
Coal	Lower Kittanning	1	8
Clay		--	6
Coal		--	10
Clay		5	--

One mile east of the tunnel, on the Ironton-Hecla road, the following strata were found:[1]

		Ft.	In.
Sandrock		6	--
Coal		--	6
Sandstone		--	6
Slate		1	--
Coal	Lower Kittanning	2	4
Slate		--	7
Coal		1	3
Fire clay		3	--
Clay shales		15	--
Ore, not measured.			
Limestone, *Ferriferous*.			

The Lower Kittanning coal and clay were worked by the Orchard Knob Brick Company while the plant was in operation. It was located about one mile north of Ironton. A section secured at this place follows:

		Ft.	In.
Sandstone		20	--
Coal	Lower Kittanning	2	4
Clay		--	7
Coal		--	8
Clay, good, plastic		6	--

In the northeastern part of the township the Lower Kittanning coal is generally thin, and lies close to the Middle Kittanning member. Further, the underlying clay is diminished in volume, and is somewhat siliceous in character. In the northwestern part, however, both coal and clay are present in force, and the coal is largely exhausted, as it has been mined for many years. A section taken east of La Grange

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[1] Geol. Survey of Ohio, Rept. of Prog., 1870, p. 197.

Furnace, on the property of John Lane, where both the Lower and Middle Kittanning coals are mined, is given below:

		Ft.	In.
Clay shale		3	6
Coal, *Middle Kittanning*		3	6
Covered		9	--
Sandstone		37	--
Shale		2	--
Coal	*Lower Kittanning*	2	1
Clay		--	1
Coal		--	10
Clay		3	--

Lawrence Township.—The Lower Kittanning coal is found above drainage along the courses of the streams that head in the western part of Lawrence Township. The coal is generally thin, somewhat shaly, and in places the bed is completely replaced by a thick sandstone. The clay underlying the coal is also poorly developed. The conditions of the members appear to indicate that this is the border of the Newcastle field.

Hamilton Township.—The areas of the Lower Kittanning members in Hamilton Township are relatively small as the beds are found near the summits of the main ridges. The clay has good continuity, but the coal is often partially or completely replaced by sandstones. In a part of the area, however, the coal is about 3 feet in thickness. As the member has not been mined, to any considerable extent, no measurements showing the character of the bed under heavy cover were obtained, but the section reported is as follows:

		Ft.	In.
Shale		4	--
Coal	*Lower Kittanning*	1	3
Coal, bony		--	1
Coal		1	--
Clay		--	2
Coal		--	10
Clay		10	--

Elizabeth Township.—Passing northward from Hamilton and Upper townships, we come to Elizabeth, in which the Lower Kittanning members reach their maximum volume in Lawrence County. The thickness and quality of the beds in this field are scarcely surpassed elsewhere in Ohio. The coal has been extensively mined for the general market, but the thick deposit of clay has been but little attacked, although the conditions are very favorable for its utilization for ceramic products. Owing to the importance of these beds, both specific and general sections of the interval will be given in order to present their extent and character in a definite way. The general character of the Lower Kittanning beds in the southern part of this township is illustrated by the following section taken at the tunnel on the Detroit, Toledo & Ironton Railway, near the village of Royerville:

		Ft.	In.
Sandstone		20	--
Coal, bony	*Lower Kittanning*	1	--
Coal		2	8
Clay		--	2½
Coal		--	8
Shale		--	4
Clay, light, good		1	4
Coal stain		--	2
Clay, light, good		2	2
Clay, dark, carbonaceous		--	4
Clay, light, good		3	--
Clay, dark, flinty nature		--	4
Clay, light, good		8	4
Clay shale, with ore nodules		3	--
Limestone, *Ferriferous*		3	--

The variations in the thickness of the Lower Kittanning coal and parting in this locality are shown by the following measurements furnished by The Ginn Company of the bed in its mine, which is located near the head of Little Storms Creek south of Vesuvius Station:

Room	Coal	Clay parting
No. 2	32½ in.	7½ in.
4	34	4
6	36	6½
8	34	7
10	39	10
12	42	5
14	36	5½
16	36	6
18	thin.	--
20	36	9
22	37	7
Entry	36	5

North of Royerville both the Lower Kittanning coal and clay have excellent volume and purity. These features are shown in the following record obtained at the limestone mines of the Hanging Rock Iron Company, which are located west of Etna Station:

		Ft.	In.
Sandstone, massive		30	--
Coal	*Lower Kittanning*	2	5
Clay		--	7
Coal		--	10
Clay		1	6
Shale		2	--
Sandstone		1	6
Shale		--	1
Sandstone		1	--
Shale, arenaceous		1	6

	Ft.	In.
Coal blossom	--	1
Clay, flint, good quality	1	--
Clay, plastic, dark, good	1	6
Clay, plastic, light, somewhat siliceous	4	6

At the mines of the Halley Coal Company at Etna Station, the upper bench of the Lower Kittanning coal varies from 2 feet to 2 feet 10 inches in thickness, the clay parting from ½ to 5 inches, and the lower coal bench from 6 to 12 inches. The average thickness of the two coal benches is about 3 feet. In this vicinity the Lower Kittanning clay has excellent volume, as it usually occupies nearly all of the interval from the coal to the underlying Ferriferous ore. A section of the coal bed taken in a mine follows:

		Ft.	In.
Shale		--	2
Coal, bony	*Lower Kittanning*	--	7
Coal		2	5
Clay		--	2
Coal		--	9
Clay		3	--

These measurements are practically duplicated at the mine of C. C. Smith north of Etna Station. Along the road north of Pedro or Etna Furnace the following record was obtained in a drift mine:

		Ft.	In.
Sandstone		35	--
Coal, bony	*Lower Kittanning*	1	5
Coal		2	1
Clay		--	2
Coal		--	8
Clay		5	--

The clay in this vicinity is quite thick, but it was not well exposed for measurement. On Storms Creek in the vicinity of Cliffside, the Lower Kittanning coal is partially or completely replaced by the massive overlying sandstone. A section secured in a cave west of Cliffside and given below shows the condition of the members:

		Ft.	In.
Sandstone		30	--
Coal, bony	*Lower Kittanning*	--	9
Shale		--	1
Coal, bony		--	5
Clay		--	4
Coal, good		--	7
Clay, good, plastic		8	--

The clay in this locality usually has excellent volume and quality. In the vicinity of Vesuvius Furnace these members have about their normal structure in most of the area. The record given below was measured north of the furnace.

		Ft.	In.
Sandstone		25	--
Coal, bony	*Lower Kittanning*	1	2
Coal		1	11
Clay		--	5
Coal		--	10
Clay		4	--

Along Storms Creek north of Vesuvius Furnace the coal is usually present, but as a general thing the bed is somewhat thin and is often shaly. Near Lawrence Furnace the Lower Kittanning coal has furnished fuel for many years and the territory is not yet exhausted. A general section of the rocks on this horizon follows:

		Ft.	In.
Sandstone		15	--
Coal, bony	*Lower Kittanning*	1	6
Coal		2	4
Slate		--	4
Coal		--	10
Clay, part siliceous, small ore nodules near bottom		4	6
Sandstone		1	--
Shale		1	6
Coal, shaly		--	9
Clay, flinty nature, dark, good		1	--
Clay, plastic nature, light, good		8	3

From Royerville and Lawrence Furnace west along Little Pine Creek the Lower Kittanning coal averages about 3 feet 4 inches in thickness and has only a thin stratum of clay intervening between the coal benches, but it is usually overlaid with about 1 foot of shaly coal or "nigger head" which is somewhat troublesome in mining. East of these places the good coal in the bed contracts and, as previously stated, it is thin and often bony on Storms Creek. On Cannons Creek the coal is below the normal in thickness, while the shaly coal or "nigger head" which overlies the main coal bench thickens to as much as 2 or 3 feet. These features are shown in the following section taken near where the Johns Creek road crosses the stream:

		Ft.	In.
Sandstone		30	--
Coal, bony	*Lower Kittanning*	1	6
Coal		1	9
Clay		--	3
Coal		--	8
Clay		3	--

One mile west of Lawrence Furnace, in Elizabeth Township, at the mine of W. R. Maxey, a good section of the Lower Kittanning interval was obtained and is given below:

	Ft.	In.
Sandstone	30	--
Shale, draw slate	--	4

		Ft.	In.
Coal, bony	*Lower Kittanning*	--	5
Coal		2	10
Clay		--	1
Coal		--	9
Clay, lower part siliceous		5	6
Clay shale		1	6
Coal, shaly		--	4
Clay, upper part flinty		11	--

The above section shows both benches of the Lower Kittanning clay to be well developed and to be separated by the thin coal bed, which is nearly always present when the lower bench of clay is found. These with the Clarion clay, which also has excellent qualities, give a total thickness of over 25 feet of ceramic material. When coal, clays, limestone, and ores are considered, this interval is extremely valuable and is duplicated at few places in southern Ohio.

One-half mile north of Lawrence Furnace, on the Edward Kelly land, the following measurements of the Lower Kittanning coal were secured in a mine:

		Ft.	In.
Shale, draw slate		--	8
Coal	*Lower Kittanning*	1	10
Clay		--	2
Coal		--	8

As this coal stratum extends northward to the vicinity of Superior, Bartles, and Dean it has slightly less volume than it has in the field near Lawrence Furnace and Royerville, but it has good continuity and quality. The bony coal which overlies the bed in the latter region is seldom present here, while the parting separating the two coal benches has about the same mean thickness. The upper bench of the Lower Kittanning clay as a general thing is somewhat thin, while the lower bench in most of the area is replaced by sandstone. At the mine of E. B. Willard near Bartles the rocks seen and reported are as follows:

		Ft.	In.
Sandstone		20	--
Coal	*Lower Kittanning*	1	8
Clay		--	1
Coal		--	10
Clay		1	6

At the mine of the Superior Portland Cement Company, south of Center Furnace, the Lower Kittanning coal has the following structure:

		Ft.	In.
Sandstone		45	--
Coal	*Lower Kittanning*	1	10
Clay		--	1
Coal		--	11
Clay		3	--

Aid Township.—The Lower Kittanning members are found along the courses of the main tributaries of Storms Creek that head in western Aid Township. The area above drainage is very small, and the coal is poorly developed. The bed, which is thin and unsteady, lies close to the Ferriferous limestone. The clays also lack volume and quality. A section taken near the mouth of Paddle Creek is given below:

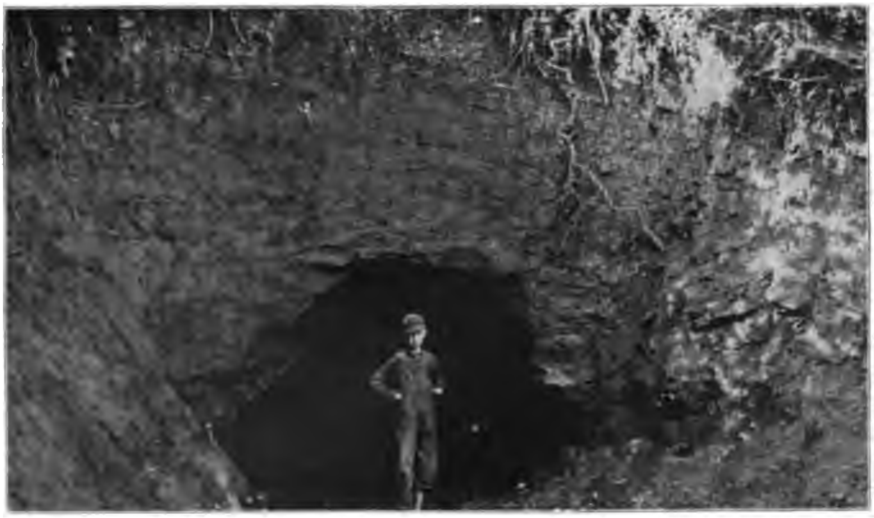
		Ft.	In.
Sandstone		10	--
Shale, with thin coal bands	*Lower Kittanning*	1	3
Coal, bony		--	8
Shale, with coal bands		1	6
Coal, good		1	5
Coal, bony		--	3
Clay		--	2
Coal, good		--	5
Clay, siliceous		2	--

The character of the bed in this locality indicates that, as it passes eastward, the good coal thins and the impure shaly layers thicken. It appears to be on the border of the main field. Further this same tendency of the bed to contract or break up as it extends eastward is also denoted by a study of the records taken in Elizabeth, Upper, Lawrence, and Perry townships.

Decatur Township.– The Lower Kittanning members are above drainage in practically all of Decatur Township. The beds are found near the summits of the main ridges in the western part, but owing to the dip eastward they pass below cover just west of the main ridge that extends northward along the eastern border. Decatur Township contains areas of thick coal and also areas of thin and broken coal. Some wants are also found. The clay has good continuity and as a general thing fair volume. The lower bench of this clay, however, is seldom present in force. Mr. J. H. Moulton reports that the Lower Kittanning coal east of the Cincinnati, Hamilton & Dayton Railway from Painter Creek south to the tunnel is thin or wanting, but south of the tunnel in Texas Hollow it shows 3 feet 6 inches of clean coal. In the hills west of this railroad from Jep Station south along the railroad and pike to the divide about 2 miles south of Moulton, the Lower Kittanning coal is also thin or wanting. In the northeastern part of the township it has good volume, while in the western part it is somewhat patchy. The following section taken east of Center Station shows the relation of the Lower Kittanning, Lost Seam, and Middle Kittanning coals and their positions with reference to the Ferriferous limestone:

		Ft.	In.
Shale		4	--
Coal	*Middle Kittanning*	2	3
Shale		--	1
Coal		--	8

A —Plant of the Ironton Portland Cement Company at Ironton.



B —Lower Kittanning coal overlaid by a massive sandstone near Forestdale, Lawrence County.

		Ft.	In.
Clay and sandstone		19	--
Coal, *Lost Seam*		3	--
Shale, with sandstone layers		1	3
Coal	*Lower Kittanning*	1	10
Clay		--	4
Coal		--	8
Clay and covered		21	--
Ore, *Ferriferous*		--	8
Limestone, *Ferriferous*		6	--

Along the road that leads from Center Station to the Superior Portland Cement plant the relation of the Lower Kittanning members to other beds was secured as the rocks were well exposed for measurement. The record follows:

		Ft.	In.
Clay, plastic, good		9	4
Coal, *Lost Seam*		2	--
Shale		1	10
Coal	*Lower Kittanning*	1	2
Shale		--	3
Coal		--	5
Clay, good		3	--
Shale		16	--

At the mines of the Superior Portland Cement Company the section is as follows, and shows the general condition of the Lower Kittanning members in this locality.

		Ft.	In.
Sandstone, massive		30	--
Coal	*Lower Kittanning*	1	10
Clay		--	2
Coal		--	8
Clay, good, plastic		5	8
Clay shale, siliceous		1	6
Sandstone, massive		15	--
Shale		1	6

From Center Station and Bartles to north of Moulton the Lower Kittanning coal is wanting, thin, or patchy. Along the pike at the head of the hollow south of Moulton the section obtained shows the following condition of the coal and clay:

	Ft.	In.
Sandstone, massive	38	--
Coal, *Lower Kittanning*	1	--
Clay, good, plastic	6	--
Covered	10	--
Limestone, *Ferriferous*	6	--

On the hill northeast of Moulton the coal is thin, but the clay, although somewhat siliceous, has good volume. The measurements follow:

	Ft.	In.
Shale	5	--
Coal blossom, *Lower Kittanning*	1	--
Clay, good, siliceous	6	--

In Branch Hollow southwest of Moulton the entire interval was not seen. The Lower Kittanning coal and Ferriferous ore were reported by David McFann:

		Ft.	In.
Slate		--	7
Coal	*Lower Kittanning*	1	10
Clay		--	4
Coal		--	10
Clay		5	--
Covered		13	--
Ore, *Ferriferous*		1	--

Mr. McFann states that the parting between the two coal benches expands in places to as much as 1 foot 6 inches, and that the lower coal bench reaches 1 foot in thickness. A section made west of the above locality in Buckhorn Hollow near the old furnace stack is as follows:

		Ft.	In.
Sandstone		10	--
Coal	*Lower Kittanning*	1	8
Clay		--	8
Coal		--	9
Clay		2	--

Near the mouth of the hollow another section taken in a mine is practically the same as the above. Along Youngs Branch no openings were seen, but the coal on the outcrop shows about the same thickness as in Buckhorn Hollow. Near the mouth of Painter Creek the outcrop shows about 3 feet of clean coal, but towards the head it is somewhat thinner. A combined section near the head of Painters Creek in the northeastern quarter of Decatur Township follows:

		Ft.	In.
Sandstone		25	--
Bone coal	*Lower Kittanning*	--	7
Clay		2	--
Coal, reported		1	--
Clay		5	--
Shale and covered		12	--
Ore, reported, *Ferriferous*		--	10
Limestone, *Ferriferous*		7	--

At the mines of the Buckhorn Coal Company, near the mouth of Nigger Creek, the section seen and reported by Mr. Isaac Day is as follows:

		Ft.	In.
Shale, good quality for brick		20	--
Coal	*Lower Kittanning*	2	2
Clay		--	8
Coal		--	10
Clay		4	--
Clay shale, bottom part siliceous		16	--

Symmes Township.—In Symmes Township the Lower Kittanning coal again appears in the bed of the stream on Buffalo and on Little Buffalo creeks at their junction and extends up each of these for a short distance. North of the Rehmer School on Little Buffalo the bed is represented by 1 foot 8 inches of bony coal. West of the Rehmer School on Buffalo 7 inches of Lower Kittanning coal was seen in the bed of the creek. It is found along Buffalo south to the first western tributary where about 2 feet of bony coal was exposed in the stream bed. The Lower Kittanning coal appears in the bed of Caulley Creek on the M. V. Thompson property. It outcrops for about three-fourths of a mile and is reported by Mr. Thompson approximately 3 feet thick under cover.

The Lower Kittanning coal appears above the waters of Symmes Creek south of McDaniel in the northeastern part of the township. The bed was mined to a small extent and is reported to be about 2 feet 6 inches in thickness.

Washington Township.—The Lower Kittanning members are above drainage in practically all of Washington Township. The beds lie well toward the summits of the hills in the western part and near the base of the hills in the eastern part. Both members are rather steady throughout the entire area. The coal is often thin, while the clay is occasionally replaced to a large extent by sandstone. On the whole there is a large quantity of valuable coal and clay yet available from these members in the field. The character of the rocks in the Lower Kittanning interval in the vicinity of Olive Station is shown in the following section taken along the road that leads to Indian Creek:

	Ft.	In.
Shale, gray, good for brick	12	--
Coal blossom, *Lower Kittanning*	2	--
Clay, plastic, good	4	--
Clay shale, siliceous	3	--
Coal blossom	--	6
Clay, plastic, good	5	6
Sandstone, white, clay-bond	5	--
Shale, with parts covered	6	--
Limestone, *Ferriferous*	5	--

Near the head of Olive Creek, Mr. James Donley reports the Lower Kittanning coal to be as follows:

		Ft.	In.
Shale		3	--
Coal	*Lower Kittanning*	2	--
Clay		--	8
Coal		1	--
Clay		2	--

In the hills west of Olive Furnace the coal is generally thin, and in places is wanting, as it is replaced by sandstones. In the hills between Bushy Fork and Brady Creek the coal is in much the same condition and the clay is often restricted in volume and siliceous in character. In a mine near the head of Brady Creek in Section 23 the condition of the coal is shown in the section given below:

		Ft.	In.
Shale		5	--
Coal	*Lower Kittanning*	1	7
Coal, bony		--	2
Clay		--	8
Coal		--	10
Clay		4	--

Along Brady Creek west of this the coal seldom expands to 2 feet 6 inches and in places it measures only about 1 foot. The clay, which is quite siliceous in the lower part, varies from 4 to 12 feet in thickness and averages about 6 feet. Near the plant of the Portsmouth Refractories Company in Spencer Hollow, northwest corner of Washington Township, the section reported by John Hanes as characteristic is as follows:

		Ft.	In.
Shale or clay, "*Oak Hill*," which latter may be plastic or flint		4	--
Coal	*Lower Kittanning*	2	2
Clay		--	1
Coal		--	6
Clay		5	--

Near the plant of the Cambria Clay Products Company in Black Fork Hollow, the section reported by the mine foreman for the mean thickness of the Lower Kittanning beds is as follows:

		Ft.	In.
Shale		3	--
Coal	*Lower Kittanning*	2	--
Clay, good, plastic		2	--
Coal		--	6
Clay, good, plastic		9	--
Sandstone		4	--
Shale, good brick		6	--
Ore, *Ferriferous*		--	4

Near the head of Irish Hollow the following section was taken:

		Ft.	In.
Sandstone		19	--
Shale		2	--
Coal	*Lower Kittanning*	1	6
Clay		--	4
Coal		--	6
Clay, plastic, siliceous at base		8	--

About one mile south of the brick plant on Black Fork, at the mine of Henry Watson, the coal has the following structure:

		Ft.	In.
Shale		2	--
Coal	*Lower Kittanning*	1	--
Coal, bony		--	½
Coal		1	--
Clay		--	7
Coal		--	8
Clay		3	--

Economic Value of the Strata in the Lower Kittanning Interval

A study of the sections shows the remarkable changes in the character of the strata that make up the interval. During their deposition the forces at work and the conditions in this old coal basin were shifting or changing continually. A plastic clay stratum in one section may be replaced by a flint clay, by a shale, or by a sandstone in the next. A coal bed may change in character, thin, or even go out completely in a short distance.

The economic value of any deposit depends not only on the value of the deposit itself, but also upon the ease with which it can be mined, and upon the value of the associated deposits. A coal bed may have good value alone, but, if a bed of clay can be worked with it, its value is increased. The success of the Oak Hill brick plants has been due largely to the fact that both coal and clay are taken from the same mine. In the Etna region, where both the Lower Kittanning coal and clay are well developed, the coal alone is mined. In a short time the mines are abandoned, and the roof left in such a condition that the clay is unavailable, or may be mined only with great difficulty. Millions of tons of clay in Lawrence County have thus been wasted.

The limestone is mined with difficulty where the overlying material is soft shale or clay, unless a part is left for the roof, but where this is sandstone the entire stratum is obtained. The shale and clay partings in the coal beds also increase the cost of mining, and if these are not well removed they decrease the market value of the fuel. These points will be taken up more in detail as the separate deposits are discussed.

Value of Lower Kittanning Clays and Shales

The next member in the series is the Lower Kittanning clays and shales, which are often partially replaced by sandstones. The clays, shales, and sandstones occupy the interval between the Ferriferous ore and the Lower Kittanning or No. 5 coal. The clay found directly above this coal in the northern part of the county should also be considered, for economic reasons, as part of this series, but geologically it is a separate member. The clays and shales of this horizon have a greater economic value than the materials from any other horizon in the county. In fact, they far surpass in value any of the coals, limestones, ores, and other clays and shales. There is a great wealth of clay material in this interval which is of most excellent quality. The thickness of the Lower Kittanning clay, shown by an average of the various sections taken throughout the region, is about 8 feet, and of the shale nearly 6 feet, or, in all, it is 14 feet. The clay is well developed in the region around Royerville and Pedro, in Elizabeth Township, where it is often 15 or more feet thick, and also at the mines of W. R. Maxey, on Little Pine Creek, where the section shows 16 feet of clay of good quality. Near Moulton and Olive Furnace the deposits are heavy, varying from

8 to 15 feet. In the northern part of the county the clays are often 12 feet in thickness, while here the shales are best developed, as they expand from 5 to 15 feet.

The importance of these vast clay deposits has not been fully recognized in this section. Clays from this horizon form the basis of the immense sewer pipe industry along the Ohio River from Steubenville to East Liverpool. Large quantities of stoneware are made from it in the Zanesville district. The large stoneware pottery industry in Pennsylvania, at New Brighton, Beaver Falls, and vicinity, uses the Lower Kittanning clay principally. It is the basis also of the fire brick industry in the same region, which is of importance. The Oak Hill, Ohio, fire brick plants use this clay to a large extent. It is also an excellent clay for the manufacture of high-grade buff, iron clay, and gray building brick. The beautiful face brick used in the construction of the Portsmouth High School were made from Lower Kittanning clay at Kittanning, Pennsylvania, although vast quantities of the same clay equally as good are found in this region only 30 miles distant. It is a source of regret that the coal has been taken from above large areas of this clay, and especially in the region where the deposits are heaviest. These clays are now practically unavailable, owing to the condition of the roof. The analyses of this clay, reported by the Hanging Rock Iron Company from its Newcastle mines, are as follows:

	Sample No. 1	Sample No. 2
Silica, SiO_2	54.80	57.60
Alumina, Al_2O_3	37.30	35.00
Ferric oxide, Fe_2O_3	.10	.12
Lime, CaO	----	.03
Magnesia, MgO	----	.15
Alkalies, K_2O and Na_2O	----	.10
Combined water, H_2O	6.20	7.00
Hydroscopic water, H_2O	1.50	----
	99.90	100.00

The analysis reported by the Ginn Company of the clay from its mines near Vesuvius Station is as follows:

Silica, SiO_2	47.83
Alumina, Al_2O_3	36.54
Iron oxide, Fe_2O_3	1.31
Lime, CaO	.98
Magnesia, MgO	.22
Ignition loss	12.98
	99.86

Mr. E. B. Willard reports the following partial analysis of the clay at his mines near Bartles Station:

Silica, SiO_2	55.58
Alumina, Al_2O_3	29.76

Iron oxide, Fe_2O_3	2.24
Lime, CaO	.69
	88.27

Sample No. 1, Hanging Rock fire clay, from Kittanning horizon. Portsmouth Firebrick Company.[1]

Silica, combined, SiO_2	53.84
Alumina, Al_2O_3	24.93
Water, combined, H_2O	11.50
	90.27
Sesquioxide of iron, Fe_2O_3	2.79
Lime, CaO	.40
Magnesia, MgO	1.50
Potash, K_2O	2.18
Soda, Na_2O	.51
Fluxing impurities	7.38
Total	97.65

In the southern part of the field the interval contains two benches or deposits of clay, the upper one just below the Lower Kittanning coal, and the lower one near the Ferriferous ore. They are usually separated by a thin coal, shale, or sandstone. In this region the lower bench is usually the best developed, and the clay is superior in quality to that in the upper bench. Near the tunnel on the Detroit, Toledo & Ironton Railway, the two beds are merged into one, but are separated again near Lawrence Furnace. Near Bartles and Center Furnace the lower bench is replaced by sandstone, or by shale and sandstone, which continue north to near Olive Furnace, where the lower bench again appears. West of Olive Furnace, and on the head of Brushy Fork, heavy sandstones take the place of the lower bench, while farther north these are replaced by shales, which continue to the northern boundary of the county. The upper bench holds its thickness well throughout the whole area. The quality varies somewhat, but is generally good.

In the northern part of the field local deposits of clay are found above the Lower Kittanning coal. In Spencer Hollow, Washington Township, from 3 to 6 feet of this clay which may be either plastic or flint are found. It is called the Oak Hill clay owing to the fact that it is well developed in the region near Oak Hill, Jackson County, where it is generally a flint clay, and where it has been used for years as the basis of the fire brick industry. It is generally separated from the Lower Kittanning coal by a shale varying from a few inches to several feet in thickness, and from the Middle Kittanning coal by 20 to 40 feet of clay, shales, and sandstones. It is here considered in the discussion of the Lower Kittanning coal and clay deposit. The economy in mining this lower bench of clay depends principally on the character of the roof, on the associated ore and on the underlying limestone. In some cases the three could be taken from the same entry as at the plant of the Ironton Portland Cement Company where the roof of the clay is a thick sandstone:

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[1] Geol. Survey of Ohio, Vol. VII, p. 222.

Coal, *Lower Kittanning*.	Ft.	In.
Clay	2–3	--
Sandstone	10–20	--
Clay	3–12	--
Ore	--	6–18
Limestone, *Ferriferous*	4–6	--
Clay	6–10	--

Considering the clay to average 7½ feet, the ore 1 foot, and limestone 5 feet in thickness, the entry would be 13½ feet in height. The clay could be taken out first, then the ore, and lastly the stone. Posts would be of little value in such workings, but if 50 per cent were available the yield per acre would be as follows:

Clay, specific gravity 2.49 = 12,711 net tons.
Ore, specific gravity 3.50 = 2,382 net tons.
Stone, specific gravity 1.68 = 9,120 net tons.

The clay should have a market value of 50 cents, ore $2.00, and stone 70 cents per net ton, so that the value of the raw products per acre would be:

12,711 net tons at $0.50 = $6,355.50
2,382 net tons at 2.00 = 4,764.00
9,120 net tons at 0.70 = 6,384.00

$17,503.50

The upper bench of clay may be mined with ease with the Lower Kittanning coal. At the Orchard Knob Brick plant, the sections show:

	Ft.	In.
Sandstone, massive	20	--
Coal	2	4
Clay, *Lower Kittanning*	--	7
Coal	--	8
Clay, good	6	--

The sandstone above forms a most excellent roof. Here both coal and clay were worked. Sixty per cent of the total should be available, and the yield per acre as follows:

Clay, specific gravity 2.49 = 13,389 net tons.
Coal, specific gravity 1.30 = 3,185 net tons.

At the mines of W. R. Maxey, near Lawrence Furnace in Elizabeth Township, the interval from the ore horizon to the Lower Kittanning coal is probably the most valuable in Lawrence County, and it is one that would be hard to duplicate elsewhere in Ohio. The clay below the Ferriferous limestone at this place is quite thick and is of fair quality. A mixture of these different clay layers is well suited for the manufacture of sewer pipe. The clay shale is suitable also for this work. The kidney ore bands average 12 inches in thickness and these, with the 8 inches of ore below, give a total of 20 inches for ore. The limestone is of good quality also. The sandstone above the Lower Kittanning coal, if crushed, has some market value. Where the cover is not too heavy, it would pay to strip the overburden, thus making the materials available in the entire interval. The section is as follows:

		Ft.	In.
Coal	*Lower Kittanning*	2	10
Clay		--	1
Coal		--	9
Clay, lower part siliceous		5	6
Clay shale		1	6
Shaly coal		--	4
Clay, upper part flinty		11	--
Clay shale, with two rows of kidney ore. Shale not good		4	--
Ore		--	8
Limestone, *Ferriferous*		7	10

From the top of the Lower Kittanning coal to the base of the Clarion clay the yield per acre would be as follows:

Clay, 27 ft., specific gravity 2.49	91,517 net tons.
Coal, 3 ft. 7 in., specific gravity 1.30	6,341 net tons.
Ore, 1 ft. 8 in., specific gravity 3.50	7,941 net tons.
Stone, 7 ft. 10 in., specific gravity 2.68	28,577 net tons.
	134,376

The clays at this horizon vary somewhat in quality in different sections and often in different parts of the same bed. In the main they are excellent plastic clays with some flint clay in pockets in both the lower and upper benches. Free silicia is usually present in the clay, but this is detrimental in a few classes of ware only, while in others it is beneficial. It should be low in ware that is required to withstand basic slag action and high temperatures. Free silica in a clay lowers the fusion point to an appreciable extent. The fusion point of the best clay used in commercial work is about 1,830° C. or 3,326° F., but this is lowered by the addition of silica until the composition, 90 per cent silica and 10 per cent alumina, is reached, when it is slightly below 1,600° C. or 2,912° F. Further addition of silica causes it to rise slightly above 1,600° C.[1] Free silica is objectionable in ware subjected to the action of basic slags. Here the bases combine readily with the silica to form low fusing compounds which soon destroy the ware. Siliceous clay ware should be used only when the slags are acid, in which case both the composition of clay and slag should be considered. It is not a desirable component in ware required to withstand sudden extreme changes in temperature, as regenerator brick, etc. Here the quartz changes at 830° C. to tridymite with an increase in volume and with a glassy texture. Severe changes in temperatures cause checking which soon leads to disruption of the ware.

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[1] Shepherd and Rankin: The Binary Systems of Alumina with Silica; Am. Jour. Sci., No. 166, Oct. 1909.

For some classes of ware free silica is beneficial, as it is more resistant to the action of acid slags than that made from the purer clays. For arch work at moderate temperatures free quartz in the ware has a tightening effect owing to the increase in volume as it changes to tridymite. The drying shrinkage of green ware is lowered by the presence of free silica unless this is very fine-grained. This component is especially beneficial in the manufacture of hollow ware such as sewer pipe, stoneware, terra cotta, fireproofing, etc., as the loss due to warping and checking is considerably lowered. The effect in burning is much the same as it lowers the fire shrinkage also. In building materials certain desirable color effects are also more pronounced when the clay is siliceous. So the effect of free silica, whether beneficial or detrimental, depends upon the uses of the ware.

There are two kinds of fluxing agents normally present in clays, acid and basic fluxes. The acid fluxes are titanic acid, phosphorus anhydride, and free silica. The effects of the latter have been given. The phosphoric acid is usually too low to exert any marked influence. Titanic acid is invariably present in all clays. In quantity it varies from a trace to as much as 3 or 4 per cent and will average approximately 1 per cent. The effect of titanic oxide is not marked, as the fusion point is lowered only about 15 degrees for each per cent present.

The basic fluxes are ferrous oxide, lime, magnesia, manganous oxide, and the alkalies, sodium, potassium, and, occasionally, lithium oxide. Ferrous oxide is an active flux. It forms two low fusing compounds with silica, fayalite, $2\ FeO.SiO_2$, and grunerite, $FeO.SiO_2$. It, with other bases, also combines with alumina and silica to form complex compounds which fuse at moderate temperatures. The color imparted to the ware by ferrous oxide, when dilute, is a bluish tint, but, as the quantities present increase, the color darkens, until a bluish-black is reached. The coloring power of the oxide depends upon the amount present, the state of fusion, and the dissemination.

The fluxing power of lime or magnesia exceeds that of ferrous oxide. With silica they react in much the same way as ferrous oxide, as they form the $2\ RO.SiO_2$ and $RO.SiO_2$ compounds. There are four definite combinations of lime and alumina, $3\ CaO.Al_2O_3$, $5\ CaO.3\ Al_2O_3$, $CaO.Al_2O_3$ and $3\ CaO.5\ Al_2O_3$, but only one between magnesia and alumina, which is $MgO.Al_2O_3$. The eutectic between silica and calcium metasilicate melts at 1,426° C. (2,585° F.), and between the metasilicate and orthosilicate at 1,440° C. (2,610° F.). The eutectic between $3CaO.Al_2O_3$

and $5CaO.3Al_2O_3$, and $5CaO.3Al_2O_3$ and $CaO.Al_2O_3$ melts at about 1,387° C. (2,515° F.). The eutectic between $MgO.Al_2O_3$ and MgO occurs at 1,950° C.[1] High magnesia is detrimental, as it gives a short vitrification range, thus making these clays very hard to burn safely. With lime, alumina, and silica there are two compounds, $2\,CaO.Al_2O_3.SiO_2$, whose melting point is not determined, and $CaO.Al_2O_3.2SiO_2$, whose melting point is 1,532° C. (2,776° F.). The compounds formed from magnesia, alumina, and silica have not been definitely determined.[2]

Sodium and potassium oxides are very active fluxes, as they form at red heat aluminates and silicates. Their fluxing action is about twice as great as that of lime or magnesia. Manganous oxide acts in much the same way as ferrous oxide. With silica it reacts to form two dark-colored silicates, $MnO.SiO_2$, rhodonite; and $MnO.SiO_2$, tephroite. The quantity present in most clays is small, but in the manufacture of gray brick manganese dioxide, which partially reduces to the lower oxide, is added. The best effects from the dioxide are obtained by adding it to siliceous clays, which, under reducing conditions, form the dark-colored silicates.

The effect on the fusion point of mixtures of these various components is complicated, but in a general way it depends on the following factors: The lowering of the fusion point increases with the number of components present, and with the quantity of each to the eutectic mixture. It also depends on the mineral components formed, and on their quantities to the eutectic mixtures. For refractory ware the total amount of bases present should be small, for in combining with the acid components the quantity of the minerals formed is considerable, for example: 1 per cent of lime combining with alumina and silica forms 4.96 per cent of the mineral anorthite. As a general rule the limit of the fluxes should be somewhere near the following; basic fluxes 4 per cent, acid fluxes 3 per cent, and total fluxes 7 per cent. Under normal conditions ferric oxide is not a flux, but a coloring agent only. A small quantity produces yellow, while increased additions deepen the color until a dark red is reached. Where considerable lime is present, dirty buffs are formed. The coloring power of the oxide is influenced, to a large extent, by the state of dissemination.

For the non-refractory grades of ware the quantity of the fluxes present is less restricted. In moderate amounts they act beneficially, as they lower the bonding temperature, thus saving fuel. In vitrified ware the quantity present should be sufficient to give a complete cementing of the mass when fused, but not enough to destroy the rigidity. The texture of the mass should be dense and stony. For common ware the kinds and quantities present should be such that the temperature range from incipient fusion to deformation is greater than that in various parts of the kiln, for if it is shorter there will be a constant loss, either to overburned or underburned ware. Each clay should be tested separately, as the effects produced by the fluxes depend on the physical and on the chemical properties of both fluxes and clays. Most clays contain small quantities of organic matter in the form of carbon or coal. The quantity is usually small, and under proper oxidizing conditions in burning it exerts no apparent effect.

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[1] Shepherd and Rankin, Am. Jour. Sci., No. 166, Oct., 1909.

[2] Shepherd and Rankin, Preliminary Report on the Ternary System, $CaO\text{-}Al_2O_3\text{-}SiO_2$, Jour. Ind. & Eng. Chem., Vol. 3, No. 4, April, 1911.

The clay at this horizon is well suited for the manufacture of several leading ceramic products. For the manufacture of refractory ware it cannot be rated as high as the Sciotoville flint clay of Ohio and Kentucky, or as high as the Mercer and Brookville flint clays of Pennsylvania. It is, however, an excellent second-grade clay, well fitted for the manufacture of general purpose ware, such as regenerator, coke oven, mill, boiler setting brick, etc. It is used to some extent, also, as blast and steel furnace linings. The Oak Hill plants have run for many years on this grade of ware, and are very successful. The few analyses given are incomplete, as they fail to show all the fluxes present. Normally, the clay is siliceous, but this is detrimental only in a few classes of ware. Heat tests, under highly reducing conditions, in the Deville furnace, on two samples from Blackfork, show Cone 32 or 3,218° F.

The working qualities of this clay are excellent. It makes plastic muds which work easily in molding, or which flow readily through the dies of the machines. The ware dries safely under ordinary conditions, either on the dry floor or in tunnel driers. The kiln loss is low when the proper attention has been given in firing. The clay contains some carbonaceous matter, which, if not properly oxidized before the fluxes begin to combine with the clay, reduces the ferric oxide to ferrous oxide, which then forms slags with silica at low temperatures. This gives dark or black cored brick. If the brick are dry when set, and if the fire is held when the brick are at a low red heat until the dark core is completely gone, then this reduction of the ferric oxide will not take place, and the brick will come out of the kiln in good condition. The total shrinkage is about 1¼ inches to the foot, but it varies somewhat with the quantity of free silica present. Grog is used in most fire brick to correct the shrinkage. Mr. D. D. Davis, president of the Ohio Fire Brick Company of Oak Hill, who has used these clays for years, says of them:

> The whole of southern Ohio, embracing Jackson, a part of Gallia and Lawrence counties, carries the Lower Kittanning bed of bituminous coal with which are found two beds of fire clay. The best deposit is the flint clay which overlies the Lower Kittanning coal, and which in some places lies directly on the coal, but almost always from 15 to 30 inches above it. The best clay in this bed carries alumina about 38 to 39 per cent, silica about 54 to 56 per cent, and iron oxide about .75 per cent. This bed is about 3 feet in thickness and is very good for fire brick, which for many uses is equal to any brick made in Pennsylvania or Kentucky, when mixed with suitable bonding clay to

give the brick the proper texture. The bed of fire clay underlying the Lower Kittanning coal directly is about 12 feet in thickness. The clay carries about 31 to 33 per cent alumina, and about 58 per cent silica. It is low in iron oxide and is one of the best second-grade plastic clays that I know. The analysis of this clay is not as good on the outcrop as given above, but will run as shown when taken from under heavy covering.

There is only one fire brick plant in Lawrence County at present in active operation. This is the plant of the Portsmouth Refractories Company at Firebrick. It is situated about one mile east of the Baltimore & Ohio Southwestern Railroad in Spencer Hollow, near the western edge of Washington Township. Mr. Wm. Hitchcock, president and general manager, reports the equipment as follows:

> The Lower Kittanning clay is used exclusively in the manufacture of our product. We use about 15,000 tons of clay per year and about 7,000 tons of coal, which is mined along with the clay. The coal provides the power necessary for the manufacture of the clay into ware and for the burning of the product. Both clay and coal are mined by hand work and conveyed to the plant on a tram road with mule power.
>
> The power plant consists of two 100-H. P. boilers, one 150-H. P. Atlas engine, and one 25-H. P. engine which is used for running the electric generator for lighting the entire plant and also the company houses. The clays are reduced in two 9-foot dry pans and one 9-foot wet pan. For tempering the clays one 10-foot and one 9-foot pug mill are used. One brick machine with an automatic rotary cutter and with a capacity of 60,000 brick per day is used for shaping some grades of ware. The machine brick are pressed in power presses. For the hand molded ware the mud is carried to the molding tables on both the first and second floors by conveyor belts. High grade hand-made brick are made on the owen floor, which is heated by exhaust steam from the engine. The same grade of shape brick are made on the second floor, which is heated by a waste heat overhead drying system.
>
> This company has nine rectangular kilns of 85,000 to 90,000 capacity each and one round kiln of 100,000 capacity. All runways are covered so that it is possible to convey brick to the kilns or to the sheds in any kind of weather. All the storage sheds are placed near the loading tracks which will hold 15 cars. This arrangement makes the cost of loading ware low. The company also has a clay mill adjoining the main factory with a capacity of four cars ground clay per day. The supply of water for the plant is secured from a large storage reservoir located near the plant. From this the water is pumped to supply tanks at the boiler room. The water in one of these tanks is heated by steam, after which it is used in tempering the clay in the wet pan and in the pug mills. All the clay is dumped on the clay yard at the place where it is to be used, and the coal is dumped from the mine cars into chutes that convey it directly to the boiler room or to the kilns. This arrangement saves much labor and loss in fuel.
>
> The capacity of the plant is 20,000 brick per day. Our ware is used for blast fur, nace linings, stoves, regenerators, annealing ovens, locomotive linings, cement kilns-rolling mill work, cupolas, coke ovens, lime kilns, and for other purposes where refractory wares are used.

The Lower Kittanning clay has good refractory qualities, as this point has been proved by practical tests where very severe strains are imposed. Mr. W. N. Jeffreys, superintendent of the Hanging Rock Iron Company, says of the fire brick which were used in relining its furnace, and which were made of the Lower Kittanning clay by the Portsmouth Refractories Company:

> Hamilton Furnace of The Hanging Rock Iron Company has been in continuous

> operation for 28 months on a lining made entirely from Ohio fire clays, or in other words, such as is produced on our property.

The Lower Kittanning clay is the clay to which he refers.

This clay ranks as one of the best in the United States for the manufacture of high grade clay building brick. The deposits are thick and can be worked with the coal above. The working qualities of the clay are excellent and the shades produced are attractive and pleasing. The section at the Cambria Clay Products Company plant on Black Fork in Washington Township is as follows:

		Ft.	In.
Shale		3	--
Coal	Lower Kittanning	2	--
Clay, good		2	--
Coal		--	6
Clay		9	--

Here the roof and floor are both good, consequently the entire 13½ feet is worked. If 60 per cent is available this should yield per acre:

Clay, 22,371 net tons.
Coal, 2,654 net tons.

The working qualities of this clay are all that could be desired. The usual procedure in the manufacture of stiff mud brick is as follows: The clay is crushed in dry pans. Because of its soft brittle nature one 9-foot dry pan will crush readily 80 or more tons per day. The ground clay is elevated from the pan to a bin from which it goes to the pug mill where water is added, and where the pugging process develops the desired plasticity. The following experiments to determine the relative plasticity of clays were made by Downs Schaaf:

> If the plasticity of clays is mainly due to a proper ratio of granular materials and active (that is, not set) colloid gels, any means of establishing the relative or absolute amount of colloids in a clay should supply a measure of its plasticity.[1] As colloids absorb dyes, this principle may be used in measuring the plasticity of clays.
>
> Three grams of malachite green for each determination were used in the following experiment. The clays were tested as received or with only enough work on them so that they would all go through a 20-mesh sieve, no grinding being done on them at all. Figured by Ashley, the relative colloid value of Tennessee ball clay is 100 colloids. Comparisons of the colloidal value of the Lower Kittanning clay from Lawrence County and of the Middle Kittanning from Nelsonville with that of Tennessee ball clay which is used as the standard are given below:

Middle Kittanning or Nelsonville clay.	Portion unabsorbed.	Relative colloids.
Through 20 mesh sieve	.850 grams	33
Through 60 mesh sieve	.110 grams	93
Through 100 mesh sieve	.083 grams	95
Through 200 mesh sieve	.052 grams	100

Lower Kittanning clay Spencer Hollow.	Portion unabsorbed.	Relative colloids.
Through 20 mesh sieve	.3000 grams	66
Through 60 mesh sieve	.0675 grams	97.5
Through 100 mesh sieve	.0204 grams	137

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[1] Ashley, Geo. H.

These experiments show the superiority of the Lower Kittanning clay over the Middle Kittanning, or when ground fine over even the Tennessee ball clay. They also show the effects of fine grinding in the development of plasticity.

The clay which has been thoroughly worked into a plastic mud in the pug mill goes to the brick machine, where it is forced out into a column which is cut into brick by hand or by automatic cut-offs. If the plasticity of the clay is too highly developed, some trouble may be experienced at this stage from lamination of the column. The best grades of brick are repressed, which develops both shape and finish. The wire-cut and repressed brick are loaded on steel cars for drying, which is done in tunnel driers using either waste heat from the kilns or steam from the boilers. These driers may be either periodic or continuous. In the periodic a tunnel is filled with cars of green brick, which are allowed to remain there until they are dry. In the continuous the cars of dry brick are taken from one end and cars of green brick are put in at the other. This clay dries safely under ordinary conditions in any type of drier. If air too highly heated is turned on the green brick, center checks or strains, which in burning develop into cracks, are produced. Most of the defects found in the burned ware originated in the drying and not in the burning. Ware made from this clay when highly plastic is subject to this defect; hence precautions should be taken in the drying.

Scumming is another common defect caused in drying. If the circulation of air in the tunnels is sluggish, moisture which is drawn from the interior of the brick, and which holds salts in solution such as sulphates, nitrates, chlorides, etc., collects on the surface. Then the evaporation of this water leaves the salts on the brick in fine beads which on burning show as a white or dirty scum. The salts, especially objectionable, are sulphates of lime, magnesia, and iron. The iron salt is derived from the weathering of the ferric sulphide present in the clay. This defect is usually remedied by the addition of barium carbonate.

$$MgSO_4 + BaCO_3 = MgCO_3 + BaSO_4$$
$$CaSO_4 + BaCO_3 = CaCO_3 + BaSO_4$$
$$FeSO_4 + BaCO_3 = FeCO_3 + BaSO_4$$

Here the barium sulphate and carbonates formed are insoluble or only sparingly soluble, so that they are fixed in the body of the clay. The burning behavior of this clay when proper attention is given to the stages or periods in burning is excellent. Prof. Edward Orton, Jr., recognizes four periods as follows:

1. **Water Smoking Period.**—It begins at the temperature of the green ware set in the kiln and lasts to 100° C. During this period the final hydroscopic water or water of plasticity is expelled.

2. **Dehydration Period.**—It begins at 100° C. and lasts to 700° C. During this period, carbonaceous matter such as leaves, twigs, etc.,

are oxidized; the combined water from most hydrates and miscellian water from colloids are given off; ferric sulphide or pyrite is broken up into ferrous sulphide and one-half the sulphur evolved; magnesium and ferrous carbonates are broken up into oxides and carbon dioxide evolved, also the magnesium oxide begins to act chemically; dolomite is broken up into the oxides and the gas carbon dioxide evolved; further the oxides begin to exert their fluxing influence; and both the molecules of water are driven off from the kaolin.

3. **Oxidation Period.**—This begins at 700° C. and lasts to 900° C. Here ferrous sulphide is oxidized to ferric oxide and sulphur evolved as gas; fossil carbon such as the fixed carbon in coal, etc., is oxidized; ferrous oxide is oxidized to ferric oxide, and during the latter part of the period the bases, lime, magnesia, and alkalies begin to exert their fluxing action to a considerable extent.

4. **Vitrification Period.**—This begins at 900° C. and lasts to complete fusion. It begins when the mass first hardens, which is shown by the beginning of the fire shrinkage, and it lasts to the point where the old mineral forms are united into a dense more or less homogeneous mass. It is a series of combinations and solutions of the various mineral components present.

These periods should be given special attention in the burning of all clay ware. The black cores frequently found in ware made from the Lower Kittanning clay are due to lack of care or knowledge in burning. If the heat in the kiln is raised too quickly, which crowds the water smoking period into the dehydration, which in turn is crowded into the oxidation, the oxidation period is then incomplete when vitrification begins, which retards further oxidation. The ferrous compounds produced form dark-colored fluid slags, which, in the presence of liberated gases, bloat and destroy the structure of the ware.

The fine glazed finish on ware made from this clay is obtained by proper care during the oxidation and vitrification periods. The ware should be completely oxidized, then during the vitrification period the flame should be so regulated that periods of oxidation are followed by short periods of reduction. This oxidation and reduction of the iron salts produce the segregation and the glazing, which give the ware a beautifully mottled and polished finish.

There is one plant in Lawrence County manufacturing high-grade building brick, the plant of the Cambria Clay Products Company, at Blackfork. Concerning this, Mr. S. P. Reitz, the secretary and treasurer, reports as follows:

> We are mining from 4 to 5 feet of fire clay, which is overlaid with Lower Kittanning coal, the thickness of which is 2 feet 10 inches. After we mine the clay the coal is taken down and is used at the brick plant. This land also contains shale, but up to the present time we have not used this class of material.
>
> The brick plant consists of one 9-foot Stevenson dry pan, one combination pug and auger machine, one automatic cut-off, made by E. M. Freese & Co., Galion, O.,

one Victor repress, manufactured by Raymond Bros. Co., Dayton, O., two 72 x 17 tubular boilers, one 125-H. P. slide-valve, Houston, Stanwood-Gamble engine, and one Ingersoll-Rand air compressor, which is used for drilling in the limestone mines, and which also furnishes air to the mine pumps. We have 8 dry tunnels with a capacity of 48,000 brick, one fan taking heat from the kilns and driving it into the tunnels, and another fan located on the opposite side taking off the moisture of the brick. We have 7 kilns with a capacity of 70,000 brick each. Clay and coal are delivered to the plant by overhead tramway. The Lower Kittanning coal is used for burning brick, and the Clarion coal for steam purposes. We employ 40 men at the brick plant, and 50 in the mines.

We manufacture face brick and machine made fire brick, making both grades out of fire clay. The building brick come out in buff shades, running from light to dark.

The building brick manufactured by this firm are very handsome buffs and iron clay mottles, the equal of any made in the State. The shades run from solid buffs to light buffs, with small iron spots, and to very dark buffs with the iron drawn out in large black blotches. The brick are vitrified; hence they are impervious to water, which qualification is in demand at present for all high grade work. These brick do not stain and weather as porous partially vitrified brick do, and they may be cleaned if necessary. The Lower Kittanning clay is used largely by the stoneware potters of this State.

The average of ten accurate and skillfully-made analyses of clay now in use shows:[1]

Clay base	56.65
Sandy matter	37.45
Fluxing matter	4.44
Moisture	1.57
	100.14
Total silica	65.09

The qualities which a clay must have to fill the various needs of a stoneware potter are essentially as follows:

1. It must be plastic, so that it can be spun and molded into any desired shape, without the expenditure of any excessive power in preparation or the use of excessive strength in turning. There is a great difference in clays in this respect, which in others meet equally well the demands of the business.

2. It must be refractory enough to stand up well and keep its shape at a heat sufficient to melt the clays used for glazes, or to take a good salt glaze on its surface. This condition is of the utmost importance; a fusible clay will cause the manufacturer a regular percentage of loss in every kiln, which can be avoided entirely by using a stronger clay.

3. While keeping its shape at this heat, it ought to be undergoing a process of vitrification which, while not being sufficiently marked to make the ware brittle or glassy, still makes the body practically impervious to water. Much stoneware is now made that does not fill this condition, as it is not vitrified at all and depends upon its glaze to make it impervious.

4. When burnt with a continuously clear fire or oxidizing atmosphere, it ought to present a clear and uniform tint, varying from light straw yellow or buff when rather soft burnt, to a clear stone gray or blue color when hard. If the clay shows, on short exposure to a smoky flame, a brown tint or scum, it will be undesirable, as it is always likely and almost sure to be exposed to reducing influences in a 40-hours burn, and a brown color is unpopular in the market.

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[1] Geol. Survey of Ohio, Vol. VII, p. 95.

5. Blotches, pimples, blisters, or any other eruption on the surface of the ware which are due to impurities in the clay and not to faults of burning, will rule the clay out, no matter if all other qualities are correct.[1]

The Lower Kittanning clay in Lawrence County has not been tested for this purpose, but undoubtedly large quantities suitable for stoneware exist as it varies from clay high in alumina to that high in silica. It is quite free from iron nodules, pyrite, and sand concretions. It is plastic and refractory, but vitrifies to a good dense body.

The Lower Kittanning coal is of good quality for burning this class of ware, and in some localities, where the clay is suitable, both coal and clay could be taken from the same entry, thus making the mining of both economical. Conditions are favorable for the establishment of this industry, as stoneware clays of excellent quality can be mined at a low cost, as the coal associated with the clay is of good quality and may be utilized for burning the ware, as the shipping facilities by rail and river are good, and as the local and western markets are open.

Another large and important branch of the clay industry is the manufacture of hollow ware, such as sewer pipe, fireproofing, and flue linings. These are made from both shales and fire clays. The three classes of ware will be considered together, as they are often made by the same machines. The main qualifications for this class of ware are the following:

1. The drying and burning shrinkage should be low in order that the strains thus produced will not crack the ware. Much ware is lost through this defect. In fireproofing the shrinkage is important also, as the limit in the size of the ware is usually very narrow.

2. They should form plastic muds in order to flow readily through the dies; but the mud should not be too plastic, as this produces lamination of the column, which later causes defects in the ware.

3. The clays should be free from hard concretionary matter, as this causes trouble in the dies, and as it generally slags during the burning, producing blisters or blotches.

4. Sewer pipe clays should be such that they vitrify to a good dense body which still retains its shape. Fireproofing and flue linings are not burned to vitrification, so but little trouble is experienced.

5. Sewer pipe clays in burning should go to a good smooth natural finish, or should take a salt glaze to produce that required. With the other classes of ware this finish is not essential.

Siliceous shales and clays usually meet these requirements, and both are found in large quantities at the Lower Kittanning horizon. At present (1913) there are no sewer pipe plants in the region, but the Cambria Clay Products Company is contemplating building a plant in the near future. The conditions for the success of a sewer pipe plant are favorable, as large quantities of available clays and shales of excellent quality for this ware are found in the region; coal of excellent quality for fuel is associated with the clays and shales; the competition is not severe, as the closest plants are near Steubenville; and the shipping facilities to the western markets are good.

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[1] Geol. Survey of Ohio, Vol. VII, p. 92.

The shales at this horizon are of good quality for the manufacture of paving, sewer, and building brick, of tile, etc. They have been used at one plant only to any considerable extent. The Petersburg Fire Brick & Tile Company, at Coalgrove, are using these shales in the manufacture of building and paving brick and of drain tile. They also manufacture fire brick from the flint and plastic clay of the Lower Kittanning horizon, and prepare ganister for the market. Mr. John Peters reports as follows:

> We have about 7 feet of plastic fire clay and about 20 feet of shale. This shale makes paving brick of the very best quality. We also have some flint fire clay. Here the Lower Kittanning coal is 40 inches thick and the Sheridan coal 38. Our brick plant has a capacity of 10,000 per day. We have a 150-horse power engine and boiler. Grinding and mixing the materials are done in one wet and one dry pan. The ware is dried on two floors and burned in 4 kilns. The company owns 275 acres of land on which are found clay, coal, and ganister.

LOWER KITTANNING COAL

The next member is the Lower Kittanning coal which outcrops in the entire western part of the county. This bed is by far the most important coal stratum in Lawrence County, and has been the main source of the local fuel supply for many years. Notwithstanding this, only a small part of the field is exhausted. The region along the Ohio River has been the most largely worked.

In Perry Township, which fronts on the Ohio River, the bed averages about 3 feet of clean coal with a clay parting of 6 to 10 inches between the lower and upper bench. On Ice Creek, below the mouth of Turkey Fork, the parting thickens locally and in one place shows 8 feet. Along the lower part of the Storms Creek Valley in Upper Township the coal has good thickness, but it thins farther up the valley or in the northern part of the township where in places only a few inches were seen. In the western part of Lawrence Township also it is thin and bony, while in Hamilton and in the western part of Upper Township, as a general thing, the bed is well developed. It reaches its maximum development in Lawrence County, in Elizabeth Township, and it has fair volume in most of Decatur and Washington townships.

The prospects of the Lower Kittanning coal holding good thickness as it extends eastward under heavy cover are not encouraging in the northern part of the field. In this region west of Symmes Creek it is easily within shafting distance. The bed in its most eastern exposure on Buffalo Creek, in the region near the Rehmer School, is bony and of little importance. On the headwaters of Pine Creek southeast of Moulton it is thin and in places is represented only by finger coal in the sandstone. On the headwaters of Little Pine and

Cannons creeks it has good thickness, but on the headwaters of Storms Creek where the coal goes under cover it is thin and bony. This condition holds southward on Storms Creek to below Cliffside. The Middle Kittanning coal comes to the surface on Buffalo and south on Symmes Creek for some distance. It goes under cover just above Waterloo. The Middle Kittanning coal is also seen on Johns Creek and its tributaries and on Aaron Creek, and it just appears in the bed of the stream on Elkins Creek. The interval from the Lower Kittanning to the Middle Kittanning coal averages about 40 feet, so that in this region the bed could easily be obtained by shafting. The Upper Freeport coal is found along the Symmes Creek Valley from the northern boundary of the county to Marion. The interval from the Lower Kittanning to the Upper Freeport coal averages about 120 feet, consequently the Lower Kittanning coal in this whole northern area from the Symmes Valley west would be available, but the indications are that it is poorly developed, especially along its eastern exposure. No drill records were obtained, but part of the territory has been prospected by the Symmes Valley Coal Company.

In the southern part of the field the prospects for the Lower Kittanning coal to hold its thickness eastward under heavy cover are slightly better. Where the Lower Kittanning coal goes under cover on Sugar Creek near the Ironton road, on Ice Creek near the mouth of Turkey Fork, and on Little Ice Creek near Forestdale, it has good thickness. On Dog and Ned forks and on Ice Creek to Rock Camp the Upper Freeport coal is above drainage, so the Lower Kittanning coal which is about 120 feet below is easily within shafting distance. No drill records were obtained. The conditions are such that this territory east of its eastern outcrop in the southern part of the county well warrants thorough prospecting.

The best part of the Lower Kittanning coal fields has been worked for many years, but large tracts of good coal are yet available. Ironton, Coalgrove, and Hanging Rock have drawn most of their fuel supply from the mines in the southern part of the field. Much of the local domestic supply is furnished by small wagon mines. The railroad mines on the Detroit, Toledo & Ironton, on the Cincinnati, Hamilton & Dayton, and on the Newcastle & Ohio River railroads furnish part of the local supply, and also ship to outside points. The most important mines in the southern part of the field are listed below.

Scherer and Hughes operate small mines at Madyville. The coal is delivered from the mines to the consumer by wagon only. They use about 9 men in mining. B. F. Lynd has wagon mines on the front hill east of Ironton and employs 6 men. The Petersburg Fire Brick and Tile Company operates mines near Coalgrove for fuel for the brick plant, and also sells some for domestic use.

The Belfont Iron Works Company operates more extensive mines for fuel at its mills and furnaces. The mines are located in the front hills east of Ironton, and the coal is taken from the mines to the works on a tram road. There are a number of small mines on Little Ice Creek, which deliver coal by wagon to Coalgrove and Ironton. Near Hecla Furnace and on Sugar Creek a few small wagon mines are operated. The Hanging Rock Iron Company works extensive mines near Newcastle, which have been in operation for many years. It mines coal, limestone, and clay, and has its own railroad, Newcastle & Ohio River, for delivering the coal from the mines to the furnaces or market. The mining along the Detroit, Toledo & Ironton Railway is the most extensive carried on in Lawrence County. The Ginn Company's mines, south of Vesuvius Station, are well up on the hill, so that the coal is taken by an incline from the mouth of the mines to the tipple at the railroad. Mr. L. W. Ault, secretary of the company, describes the equipment as follows:

> For power in hauling we are using a Davis storage battery mine locomotive which is only 28 inches high and which does most of the gathering. The large haul from lay off to top of incline is still done by mules. Our coal is let down from the top of the hill to tipple by means of a drum and wire rope; the load going down pulls the empty up. We have a 20-horse power generator run by a gasoline engine, which operates the fan also, for recharging the battery in our locomotive. When running full we employ about 50 men.

Mr. C. C. Smith, who operates mines north of Etna Station, hauls the coal in wagons to the cars at the Etna switch. He works about 20 miners and 5 men with teams. The Halley Coal Company has operated shipping mines in the vicinity of Etna Station for many years. The mines are level-free, and the hauling is done by mule power. The capacity, under normal conditions, is reported to be about 200 tons per day. W. R. Maxey mines the lower Kittanning coal, near Lawrence Furnace, along with limestone and clay. The equipment is described under Ferriferous limestone mines. The total men employed in mining by him is 30. A few small wagon mines are also in operation near Lawrence Furnace. E. B. Willard mines some coal at Bartles. The equipment has been given, and the output is about 400 cars per year. A few small mines are being worked for local use near Center Station. The Superior Portland Cement Company mines the Lower Kittanning coal for steaming purposes and for local domestic use. Its mines near the plant are electrically equipped with power for hauling and cutting, and are also lighted by electricity. It also works a few wagon mines south of the plant. There are a few mines in the northern part of the field east of the Baltimore & Ohio Southwestern Railroad in Washington Township, the most important of which are given below. The Portsmouth Refractories Company mines the Lower Kittanning coal and its associated clay. The coal is used for fuel in burning the fire brick, and for local domestic use. The clay and coal are brought from the mines to the plant by a tram road. The York Portland Cement Company formerly operated mines in Spencer Hollow.

The Cambria Clay Products Company works the Lower Kittanning coal and the associated clay. The coal is used for burning brick and for local domestic purposes. Formerly these mines were operated on a large scale, and were electrically equipped. The hauling was done with motors and the cutting with machines, but at present the mining is done by hand and the hauling by mules.

At present the equipment in most of these mines is comparatively simple. The ventilation is produced by shafts, furnaces, or fans in the larger mines, but in the smaller ones the only ventilation is through old works. The drainage is natural or by ditches in most cases, although a few are drained by means of pumps. The mining in general has been unsystematic and wasteful, owing to the haphazard method of driving entries and working rooms. A few of the larger mines have been worked with more economy, as they have been properly surveyed and plotted. The usual method pursued by the small operator is to drive an entry until he can turn two rooms, which are worked almost any width and length as long as the air is good, and as long as the distance to "buggy" the coal is not too great; then the entry is driven until he can turn two more rooms, which are worked in the same manner. The result is the coal along the outcrop is worked out, while good blocks, which are unavailable, or can be mined only with considerable dead expense, are left farther in the hill.

The roof material of the Lower Kittanning coal in the entire southern part of the field is a massive sandstone, but in the northern part this is replaced by clays and shales. In general the roof is excellent and the mining conditions fair.

The character of the bed is such that the coal mines more or less dirty. Normally it is made up of two coal benches with a clay parting intervening, the thickness of which varies greatly. In that part of the field around Royerville, Etna, and Lawrence Furnace this parting is often less than one inch thick, but in the northern part of the field, around Blackfork, it thickens in places from 1 to 2 feet. The maximum is found on Ice Creek, where the parting is 8 feet. The average is about 5 or 6 inches. In places a thin bony band is found about the middle of the upper bench, but this seldom reaches over 1 inch in thickness. The "nigger head" or shaly coal found above the upper bench is a part of the member. In that part of the field on Little Pine Creek, where the coal is best developed, this shaly coal is also quite thick, often reaching 18 inches. It is made up of coal interstratified with bands of carbonaceous shale. It does not have the tough nature of a shale, but is blocky and brittle much like coal. In Spencer Hollow a heavy plastic or flint clay is found above the coal. This makes a very poor roof, owing to the crumbly and brittle nature of the clay.

The quantity of deleterious material in the mined coal depends on the structure of the bed, on the method of mining, and on the care exercised. At present but little coal is cut by the pick. The usual method is to "shoot off the solid," which requires much harder shooting than where bearing-ins have been made. This not only breaks up the coal severely, but also breaks up the clay and "nigger head" which come down with the fuel. The larger pieces of clay and "nigger head" are picked out, but the finer pieces are loaded. The lump coal that passes over the screen is fairly clean, but the nut and slack coal contains all this fine deleterious material which makes the quality poor, and consequently makes the market value low. In many of the mines, after picking out the large pieces of clay and "nigger head," the coal is forked, which leaves considerable nut and slack coal, and fine impurities in the mine. This method is wasteful, as much good fuel that should be utilized for some purpose is allowed to remain in the works. The quality of the Lower Kittanning coal is shown by the following analyses:

Lower Kittanning coal from the mine of John Peters, Coalgrove, Lawrence County. This is one of the southernmost mines of the state. The coal is used in burning brick and two or three mines are kept regularly at work. The sample was taken about one mile from the entrance where there was a vertical cover of 100 feet. While considerable water was in the mine, the sample was cut in a dry place and measured 5 by 3 inches. Sampled by D. D. Condit in November, 1907. Chemical analysis and calorific value of sample:

Ultimate		*Proximate*	
Carbon	66.71	Moisture	7.57(a)
Hydrogen	5.59	Volatile matter	38.51
Oxygen	14.44	Fixed carbon	45.13
Nitrogen	1.27	Ash	8.79
Sulphur	3.20		
Ash	8.79		

Calorific value $\left\{\begin{array}{l}6{,}777\text{ calories.}\\ 12{,}199\text{ B. t. u.}\end{array}\right.$

(a) Moisture in air dried sample from 2½ to 3 per cent.[1]

Sample from mine No. 2 of the Halley Coal Company, Etna Station, Lawrence County. Sample taken about 1,500 feet from entrance and where there was a vertical cover of 50 feet. The sample was cut from a fresh face and measured 5 by 3 inches. Taken by D. D. Condit in November, 1907. Chemical analysis and calorific value of sample:

Ultimate		*Proximate*	
Carbon	65.54	Moisture	8.07(b)
Hydrogen	5.44	Volatile matter	34.54
Oxygen	15.95	Fixed carbon	47.68
Nitrogen	1.23	Ash	9.71
Sulphur	2.13		
Ash	9.71		

Calorific value $\left\{\begin{array}{l}6{,}626\text{ calories.}\\ 11{,}927\text{ B. t. u.}\end{array}\right.$

(b) Moisture in the air dried sample from 2½ to 3 per cent.[2]

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[1] Geol. Survey of Ohio, Fourth Series, Bull. 9, p. 189.

[2] Geol. Survey of Ohio, Fourth Series, Bull. 9, p. 190.

The analysis of the coal, reported by the Ginn Company from its mine, is as follows:

	Top	Bottom	Full bed
Volatile matter	40.30	40.53	41.15
Fixed carbon	52.32	53.27	49.10
Ash	5.04	4.14	9.75
Sulphur	2.33	2.02	2.25
Moisture	----	----	2.50

> Analyses of the top and bottom benches were made by the Belfont Iron Company and of the full bed by the Ashland Coal & Iron Company, Ashland, Ky. The latter company also took a car of our coal and washed it in its plant at Ashland. Then it was pulverized and made into coke, with the result that we got as nice looking a product as is on the market. The analysis of the coke is as follows:[1]

Volatile matter	2.95	2.60
Fixed carbon	86.60	88.85
Ash	10.45	8.55
Sulphur	1.004	1.350

Mr. E. B. Willard reports the analysis of the Lower Kittanning coal from the Newcastle mines as follows:

Moisture Volatile matter	46.94
Fixed carbon	45.92
Ash	7.14
Sulphur	2.126

Mr. W. M. Jeffreys says of this coal:

> It is an excellent steam coal. The bed is 42 inches thick, and we have our mine in operation. The tests that have been made with this coal show that by a mixture of a small percentage of Pocahontas coal an excellent grade of coke can be produced.

The Lower Kittanning coal has been coked for years by the Ashland Coal & Iron Company at Ashland, Ky. The coke produced is of fair quality, but the yield is low. Since the introduction of the retort oven, many coals that made poor coke, or gave low yields in the beehive ovens, are now important. Either alone or mixed with other coals they make good coke, and valuable by-products are saved.

This coal has a good reputation for steam purposes. It is a free-burning long-flamed coal, and the ash clinkers but little. It is also an excellent coal for burning clay products, especially building brick, sewer pipe, or tile, as the color is developed mainly by the impinging of the flame on the ware. The calorific value compares favorably with that of other coals of the State. The Lower Kittanning coal has a fair reputation as a gas coal, but has not been extensively used for this purpose. The shipping qualities are rather poor, as the coal is soft and breaks up easily in handling.

The Lower Kittanning coal, considered from every point, is by far the most important coal bed in Lawrence County, as the area available is large, as the quality is equal or superior to other coals in the county, as the mining conditions are fair, as the associated clays are of excellent quality, and as it has possibilities in the manufacture of retort coke and valuable by-products.

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[1] Personal letter dated Dec. 26, 1912.

"LOST SEAM" COAL

This coal is locally known as the "Lost Seam," owing to the fact that it is found only in one region, and that covers but a few square miles of territory. The bed is best developed in the region near Center Station, in Decatur Township, where it reaches a thickness of 3 feet. South of this area it is replaced by heavy sandstone, and north by sandstone as far as the northern part of Washington Township where the shales appear. Its position is from 1 to 6 feet above the Lower Kittanning coal, from which it is separated by shale or clay. In the hill south of Center Station the following section, which shows its relation to the Lower and Middle Kittanning coals, was taken:

		Ft.	In.
Coal	*Middle Kittanning*	2	3
Clay		--	1
Coal		--	8
Clay and sandstone		19	--
Coal, "*Lost Seam*"		3	--
Shale and shaly sandstone		1	3
Coal	*Lower Kittanning*	1	10
Clay		--	4
Coal		--	8

This bed was traced eastward to the Cincinnati, Hamilton & Dayton Railway, but was not seen beyond this. Along the road on the divide from Center Station to Center Furnace the following section was taken:

		Ft.	In.
Coal blossom, *Middle Kittanning*		1	--
Clay		1	--
Sandstone, nodular		1	--
Shales, gray		8	--
Coal blossom		--	2
Clay, good		9	4
Coal blossom, "*Lost Seam*"		2	--
Shales		1	10
Coal	*Lower Kittanning*	1	2
Clay		--	3
Coal		--	5
Clay		3	--

The "Lost Seam" has been mined in a small way here, and under cover shows 3 feet solid block coal. This bed extends south only a short distance. On the second knob, one mile due north of Center Station, the following section was taken on the outcrop:

		Ft.	In.
Sandstone, massive		20	--
Coal	*"Lost Seam"*	--	8
Clay		--	5
Coal		--	7
Clay and clay shale		5	--

One-half mile farther north a section was measured up the hill on the road that goes from Center Station to Poplar Flats, and is given below:

	Ft.	In.
Coal blossom, *Middle Kittanning*	1	--
Sandstone, massive	39	--
Coal blossom, *Lower Kittanning*	2	--

This section shows that the "Lost Seam" is wanting, as it has been replaced by sandstone. It disappears in about one-half mile, and is not found farther north. A section was taken near the head of the first hollow east and north of the Superior Cement plant which shows the "Lost Seam." This section is as follows:

	Ft.	In.
Coal blossom, *"Lost Seam"*	1	--
Shale	4	--
Coal blossom, *Lower Kittanning*	2	--
Clay	2	--

The "Lost Seam" was not found either north or west of this hollow. It is confined to a few square miles only. It is not a part of the Lower Kittanning member, but distinctly a separate deposit.

Economic Value

This "Lost Seam" is of small importance. In part of the territory, especially around Center Station, it lies near enough to the Lower Kittanning coal to be mined with the latter. Where the shale thickens to several feet, this cannot be done. The coal is of poor quality. It has many plant markings in which thin pyrite bands are found, and the ash is reported high.

OAK HILL CLAY

The only area in Lawrence County in which the Oak Hill clay was seen is in Spencer Hollow, where it lies close to the Lower Kittanning coal, as shown by the section taken at the mine of the Portsmouth Refractories Company, which is as follows:

		Ft.	In.
Sandstone		10	--
Clay, *Oak Hill*, which in places changes to a good flint clay		4	--
Coal	*Lower Kittanning*	2	2
Clay		--	1
Coal		--	6
Clay		5	--

In this locality a few feet of shale often separate the Oak Hill clay from the underlying Lower Kittanning coal. This is the case also in the northern part of Jackson County, but near Oak Hill it often lies directly on the coal.. The deposits of this clay in Lawrence County are very local, and have not been utilized as yet. For a more complete description of this member the reader is referred to this subject in the report on Jackson County, where the Oak Hill clay is treated at some length.

MIDDLE KITTANNING, SHERIDAN, HOCKING, OR No. 6 COAL

The Middle Kittanning is one of the most important coal members in Ohio. This bed, which has notable thickness in the Hocking Valley region in its extension southward, thins so that it becomes of far less value. Small areas of good coal are found, however, in Vinton, Gallia, and Lawrence counties. In its extension southward from Lawrence County into Kentucky it appears again in force. In Lawrence County the Middle Kittanning coal is best developed in the Sheridan District, in Perry Township, while isolated pockets of coal are also found in Upper, Elizabeth, Decatur, Washington, Symmes, and Aid townships. The Middle Kittanning coal is found generally from 35 to 40 feet above the Lower Kittanning coal, and from 65 to 90 feet below the Upper Freeport. See Map VI facing page 390.

Perry Township.—The Middle Kittanning coal has good volume in the Sheridan District, in Perry Township, where it was formerly mined in a large way for coaling steamboats on the Ohio River and for river shipment. At present only small mines are operated to supply local domestic needs, although large areas of coal are yet available. Owing to the value of the bed in this district it will be traced with some care.

On the Hecla property, along Pancake Branch of Ice Creek, the Middle Kittanning coal was opened and worked at one time, and is reported by Mr. Charles Campbell to be 42 inches thick. On the property of Josephine Ball this bed has been worked in a small way. No mines are open at present, but Mr. Edward Cannon reports it from 20 to 42 inches in thickness. It has been worked in a few places near the mouth of Turkey Fork, but appears thin and irregular. Along the lower course of Little Ice Creek the Middle Kittanning coal is thin, and in places is represented only by the clay. Towards the headwaters, however, the coal is present in force. Just east of Forestdale, on the property of John Pancake, the following record was obtained, where the coal was well exposed for measurement:

	Ft.	In.
Shale	--	1
Coal, *Middle Kittanning*	3	11
Clay	2	--

The coal was opened by a drift mine here at one time, and is reported to vary in thickness from 3 feet 6 inches to 4 feet 6 inches. South and east of this, on Little Ice Creek, to where the bed falls below drainage, it is reported to be somewhat patchy. Near where it passes below drainage, however, it again expands to about the normal volume for this coal in the Sheridan District. This is shown by the record given below, which was taken on the farm of G. W. Graham·

	Ft.	In.
Sandstone	12	--
Coal, *Middle Kittanning*	3	6
Clay	1	--

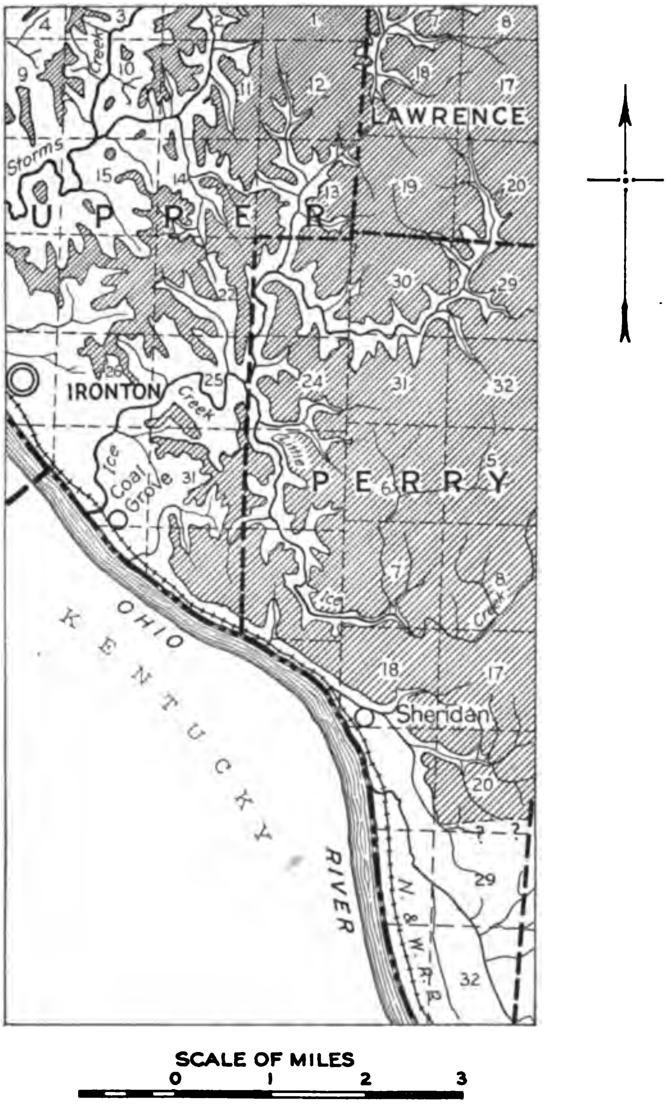
Mr. Graham reports that the coal in this locality averages about 3 feet 6 inches in thickness. East of this the Middle Kittanning coal has been mined by stripping on the property of Edward Crabtree who reports the bed to be 4 feet 5 inches in thickness. This member has good volume on Little Ice Creek, where it passes under cover. Along the Ohio River, north of the village of Sheridan on the land of the Sheridan Coal Company, this coal was mined for a number of years, but the territory is not yet exhausted. No good exposures were found, but the bed is reported to average about 3 feet 6 inches in thickness. This statement is borne out by the measurements of the member obtained at mines on the land of Charles Chatfield, on the branch of Lick Creek north of Sheridan. The record follows:

	Ft.	In.
Clay	2	--
Coal, *Middle Kittanning*	3	6
Clay	2	--

In this locality the shale below the sandstone is stated to vary from 1 foot 6 inches to 2 feet, while the clay above the coal varies from 2 feet to 2 feet 6 inches. The coal bench expands from 3 feet 6 inches to 3 feet 11 inches and is not separated by clay or bony coal partings. In this hollow small wagon mines are operated for the local fuel supply. The clay above the coal makes a rather unsatisfactory roof, but it may be held up by careful posting and by driving narrow works. On Lick Creek, the Middle Kittanning bed passes below drainage about one mile east of the flood plain of the Ohio River. The bed is quite persistent and has good volume along this stream. On the farm of Henderson Rickman the following measurements were obtained in a drift mine:

	Ft.	In.
Clay shale	1	--
Coal, *Middle Kittanning*	3	3
Clay	1	--

In this locality north of Lick Creek, the coal is reported to average about 3 feet 6 inches in thickness, and to vary from 3 feet 3 inches to 3 feet 11 inches, while south of the stream, the bed is stated to average 2 feet 10 inches and to vary from 2 feet 6 inches to 3 feet 4 inches. There is quite a good area of Middle Kittanning coal above drainage, MAP VI.



Middle Kittanning or No. 6 Coal in the Sheridan Field, Lawrence County.

in the Sheridan District, that is undeveloped. From surface indications the coal appears to be rather steady and to have good volume. Furthermore, as the bed is present in force, where it passes below drainage on Little Ice and Lick creeks, it is reasonable to expect the coal to extend with the same volume under cover for at least a short distance. Drill records east of this appear to indicate that it extends eastward across the county, but the tests are too scattered to obtain an opinion on the continuity of the member.

Upper Township.—In Upper Township there are only small pockets of Middle Kittanning coal that have sufficient thickness for regular drift mining. In the greater part of the area the bed, if present at all, is marked only by a thin layer of impure coal. The best pockets of coal will be described.

Near Coalgrove, on the property of the Petersburg Fire Brick and Tile Company, the Middle Kittanning coal is reported by John Peters to be well developed. The mines had all fallen in, so that the coal was not seen. The section reported is as follows:

	Ft.	In.
Clay, good, used for brick	2	--
Coal, *Middle Kittanning*	3	2
Clay, good, used for brick	6	--

The Middle Kittanning coal is worked at present in Upper Township on the Sailor property on Sugar Creek near the Ironton road, where the section is as follows:

		Ft.	In.
Coal	*Middle Kittanning*	1	7
Shale		--	1
Coal		1	7
Clay		2	--

This is only a local pocket and the bed thins west on Storms Creek. Near the road on the divide from Storms Creek to Lagrange Furnace, the Middle Kittanning coal has been opened and mined on the John Lane property, but the area of workable coal is small. The section is as follows:

	Ft.	In.
Shale	3	6
Coal, *Middle Kittanning*	3	6

Lawrence Township.—North of the Sailor pocket on the headwaters of the tributary of Storms Creek in Lawrence Township, the Middle Kittanning has been opened in a few places, where J. H. Keys reports the coal to be 1 foot 3 inches thick.

Elizabeth Township.—North of the above, it is generally thin and of little value as far as Center Station in Elizabeth Township, where there is another small pocket of Middle Kittanning coal, which [illegible] [illegible] Shale and Lower Kittanning. A section wi[illegible] [illegible] is as follows:

		Ft.	In.
Shale		4	--
Coal		2	3
Clay	Middle Kittanning	--	1
Coal		--	6
Clay and sandstone		[illegible]	--
Coal, [illegible]		3	--
Shale and sandy [illegible]		1	3
Coal and parting, Lower Kittanning		2	10

The Middle Kittanning coal is very irregular and is reported by the miners to expand from 20 to 41 inches in this locality. North of [illegible] the blossom indicates that the coal is thin or irregular.

Decatur Township.—The Middle Kittanning coal in Decatur Township is rather persistent, but with few exceptions the bed is too thin to be mined by drifting. In Texas Hollow, J. H. Moulton reports the Middle Kittanning coal to be 3 feet thick. In this township, at the tunnel of the Cincinnati, Hamilton & Dayton Railway, a section was taken which is as follows:

		Ft.	In.
Clay shale, dark		--	7
Coal		--	7
Clay	Middle Kittanning	--	1
Coal		--	6
Clay		1	--

This coal here is very irregular, as it thins and thickens erratically, and in places disappears completely. North of Poplar Flats, a few small pockets were reported. On the head of Nigger Creek, a blossom 2 feet in thickness was seen near the foot of the hill.

Washington Township.—The Middle Kittanning coal in Washington Township, although somewhat thin, has been mined at many places in the northern part of the area, while in the southern part it is quite thin and often wanting. On Olive Creek the blossom of this member from 1 foot to 1 foot 6 inches in thickness was noted in a number of places, while on Brady Creek the outcrop of the bed indicates that it is generally thin and often replaced by thick sandstones. No mines working this coal were seen on the creek. In Spencer Hollow it is also thin and of no importance. On Black Fork, east of the plant of the Cambria Clay Products Company, it has been mined. The entries were fallen in, so the coal was not seen, but Henry Watson, who worked in these mines, reports the bed as follows:

		Ft.	In.
Shale		4	--
Coal, generally bony	Middle Kittanning	--	6
Clay		--	6
Coal, good		1	8
Clay, siliceous		2	--

Near the head of Irish Hollow, where it was also mined, the foreman reports the section as follows:

	Ft.	In.
Clay shale	1	--
Coal, *Middle Kittanning*	1	10
Clay, containing nodules	3	--

He also reports that the quality of the coal is good, but that it thins down to 6 inches or less in places. It has also been worked some for local use near the head of Black Fork, where the thickness is practically the same as in Irish Hollow.

Aid Township.—The Middle Kittanning coal is above drainage in the northern part of the basin of Symmes Creek. On Elkins Creek, in Aid Township, above Oak Ridge Furnace, the coal is found in the creek bed for a short distance. Mr. John Waugh reports that it is 1 foot 6 inches thick. On Aaron Creek it may be seen above drainage for a short distance. On the property of S. D. Griffith it has been opened in the bed of the stream, where he reports it 2 feet thick and of good quality. A small mine was worked about one-half mile farther down the creek. Here Mr. Griffith states that the coal on the outcrop is about 2 feet thick, but that it thins to a few inches as the bed is followed into the hill.

Symmes Township.—On Johns Creek, in Symmes Township, the Middle Kittanning coal is above drainage from Sherritts to near its headwaters, and it is found on the northern tributaries, Buckeye, North, and Slab forks, well up their courses. It has been opened in a few places on Johns Creek, but as all the workings have fallen the coal was not exposed for measurement. It was worked some for local use on the property of Mr. Alfred Keller, near the head of the creek. He reports the bed to have a maximum thickness of 4 feet, but to lie in pockets which thin to a few inches. A section in one of his mines is reported as follows:

		Ft.	In.
Clay and shale		3	--
Coal	*Middle Kittanning*	2	--
Parting		--	3
Coal		1	--
Sandstone		8	--

He reports the coal to lie between two sandstones, which, in places in whole or in part, replace the coal. Near the head of Slab Fork one foot of coal was seen in the bed of the creek. Farther down it has been opened and worked in a small way for local use. A section in a mine shows the following:

		Ft.	In.
Clay		--	3
Coal	*Middle Kittanning*	1	5
Shale		--	1
Coal		--	10
Shale		1	--

The Middle Kittanning coal has also been opened and worked on the property of A. Neal, who reports that it lies in pockets, which vary in thickness from a few inches to 3½ feet. On North Fork, in Symmes Township, it has been mined in a small way for local use. On the property of W. H. Boggs, along this stream, a section was taken in a mine south of his residence, which is as follows:

		Ft.	In.
Clay, plastic		1	6
Clay, siliceous		--	6
Clay, flint		--	2
Coal	*Middle Kittanning*	1	--
Shale		--	1
Coal		2	--
Clay		2	--

North of the house Mr. Boggs reports the bed thin, as shown by the next section:

	Ft.	In.
Clay	2	--
Coal, *Middle Kittanning*	1	3
Clay	1	--

Near the head of the creek it has been mined in the bed of the stream, where Oliver Dennin reports about 3 feet of coal. On Buckeye Creek the bed, only a few inches in thickness, was observed at a number of places. Near the head of the creek in the bed of the stream it is as follows:

	Ft.	In.
Clay	2	--
Coal, *Middle Kittanning*	1	3

On these streams the pockets of Middle Kittanning coal are small, and are of importance only for local domestic use.

In the Symmes Creek Valley the Middle Kittanning coal is found near the bed of the stream about one mile north of Waterloo. Here it is represented by only a few inches of coal, which condition is maintained to near the mouth of Buffalo Creek, where it thickens locally. On the property of T. H. Neal it and the Upper Freeport coal have been opened. The section is as follows:

		Ft.	In.
Slate		--	4
Coal	*Upper Freeport*	--	6
Clay and clay shale		1	1
Coal		3	2
Covered		70	--
Sandy shale		5	--
Coal	*Middle Kittanning*	--	3
Clay		--	3
Coal		--	9
Bone coal		--	3
Clay		--	6
Coal		1	10½
Clay		--	1
Coal		--	2½
Clay		2	--

On Buffalo Creek the Middle Kittanning member, where found, is represented by only a few inches of coal. Near the head of the creek, just east of Phillips Knob, J. W. Yates reports it to be 2 feet thick. Near the head of the tributary south of this it has been opened, and is reported to be 3 feet thick on the outcrop, but to thin to 6 inches when followed into the hill. On Indian Creek, near the home of Thomas Miller, it has been worked for local use. A section taken in a mine on his farm is as follows:

		Ft.	In.
Shale, with thin coal bands		2	6
Coal	*Middle Kittanning*	1	7
Clay		--	1
Coal		--	8
Clay shale		2	--

Mr. Miller reports that in the hill it has a maximum thickness of 3 feet 10 inches. On the property of John Rehmer, east of the above, it has been prospected, and he reports: "In one opening it showed 15 inches on the outcrop, but in the hill this thinned rapidly, and soon disappeared entirely. In another opening, only a few rods away, it was 3 feet thick." On Caulley Creek there are a few pockets of Middle Kittanning coal, which M. V. Thompson reports to have a thickness of 2 to 4 feet in places. It has been opened and worked some for local use, and the member has the following structure in a mine on land of Warren Slagel, in Section 9:

	Ft.	In.
Clay shale	1	2
Coal, *Middle Kittanning*	2	6
Clay	1	--

The bed, where found on Miller Creek and in Carpenter Hollow, is thin, and no mines were noted in this locality.

Economic Value

Excepting the small area near Sheridan the Middle Kittanning or No. 6 coal in Lawrence County is of small importance, as it is developed to a workable thickness in pockets only. The quantity of coal in this bed, however, if properly worked, is sufficient to furnish the local fuel supply for many years in the central part of the county. The coal is of fair quality. An analysis of a sample from the mine of G. L. Chatfield, Sheridan, is as follows:[1]

Ultimate		*Proximate*	
Carbon	64.95	Moisture	6.64(a)
Hydrogen	5.16	Volatile matter	34.28
Oxygen	14.42	Fixed carbon	48.16
Nitrogen	1.23	Ash	10.92
Sulphur	3.32		
Ash	10.92		
	100.00		100.00

Calorific value { 6,626 calories.
11,927 B. t. u.

(a) Moisture in the air-dried sample from 2½ to 3 per cent.

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[1] Geol. Survey of Ohio, Fourth Series, Bull. 9, pp. 202-203.

The quality of the coal is excellent for domestic and steam purposes. It is a free burning fuel with a moderate amount of ash, which does not clinker in the grates. As shown by the sections, the root in part of the field is very poor, as it is either a soft jointed shale, or a soft clay, or a draw slate between the coal and sandstone above. In some places, however, the roof is good as it is a sandstone or a tough shale. All the mines working this bed at present are small and the coal is hauled by wagons. Formerly a few railroad mines were operated on Black Fork in Washington Township. The mines were electrically equipped and the coal loaded from a well built tipple into the railroad cars, but as the coal is too thin and broken for successful mining in this manner, the operations were abandoned.

The clay associated with the coal in some parts of the field is of fair quality, but this, like the coal, is uncertain in extent. No works of importance should be based on this clay and coal without thorough testing and prospecting.

YELLOW KIDNEY ORE

Between the Middle Kittanning and Lower Freeport coals there occurs in places in Lawrence County a bastard limestone bed, which is often very ferruginous. In fact, along the outcrop it is often an iron ore and is characterized by a high content of phosphorus, which makes it valuable for some grades of iron. This deposit is best seen in small areas in Hamilton, Upper, and Elizabeth townships. The thickest deposit of ore noted on this horizon was in Mile Hollow, on Osborn Run on the property of the Hanging Rock Iron Company, where the following record was obtained:

	Ft.	In.
Clay, bluish, plastic	3	--
Ore, *Yellow Kidney*	3	6
Sandstone and covered	44	--
Sandstone	20	--
Coal horizon, *Lower Kittanning.*		

The Yellow Kidney is a calcareous, high phosphorus ore with sufficient iron to make it worth while for furnace use. As a general thing it is more than self-fluxing, which adds materially to its value. There are two benches of the ore, the upper one of which carries the largest percentage of iron. This ore was used to a small extent by the charcoal furnaces, and has also been used occasionally by the present furnaces. An analysis of the ore furnished by the Hanging Rock Iron Company follows:

Iron, Fe	34.00
Silica, SiO_2	5.85
Alumina, Al_2O_3	3.66
Lime, CaO	10.50
Magnesia, MgO	0.38

Sulphur, S	0.068
Phosphorus, P	2.393
Manganese, Mn	0.94
Ignition loss	13.60
Hydroscopic water	2.00

LOWER FREEPORT, HATCHER, OR No. 6a COAL

Usually the Lower Freeport coal is found about 40 feet above the Middle Kittanning coal, and about the same distance below the Upper Freeport. These intervals, however, vary from 30 to 50 feet. In Lawrence County, the Lower Freeport coal is best developed in Perry Township, although it is represented in southwestern Fayette, eastern Upper, Lawrence, eastern Elizabeth, Aid, Symmes, eastern Decatur, and eastern Washington. A few sections are given to show the structure of the bed and to show the general character of the materials in the interval from the Middle Kittanning to the Upper Freeport coals. A section taken in Decatur Township, on the divide from Center Station to Center Furnace, is as follows:

	Ft.	In.
Coal blossom, *Lower Freeport*	1	--
Clay	2	--
Shales, gray	22	--
Sandstone, nodular	2	--
Shales, arenaceous	7	--
Sandstone, medium bedded	14	--
Shales and covered	2	--
Sandstone	1	--
Coal blossom, *Middle Kittanning*	1	--

North of Dean, at the tunnel on the Cincinnati, Hamilton & Dayton Railway, the following section was measured:

	Ft.	In.
Coal, *Lower Freeport*	1	--
Clay	2	--
Sandstone, part shaly	14	--
Shale	10	--
Coal stain	--	2
Clay, good	4	--
Shale, siliceous	4	6
Sandstone	--	1
Clay shale, dark	--	7
Coal, *Middle Kittanning*	1	2

A section found along the pike one mile north of Waterloo, in Symmes Township, is as follows:

	Ft.	In.
Coal blossom, *Upper Freeport*	1	--
Shale and covered	12	--
Sandstone, massive	5	--
Shale, arenaceous	13	6
Shale, dark, tough	1	--
Ore	--	2

	Ft.	In.
Shale, soft, gray	--	4
Coal, *Lower Freeport*	--	6

In the western part of Lawrence Township, near the head of the stream that rises near Kitts Hill, the Lower and Middle Kittanning and the Lower and Upper Freeport coals are represented. The section is as follows:

	Ft.	In.
Clay, part flint, place of *Upper Freeport* coal	2	--
Shale and shaly sandstone	44	--
Coal stain, *Lower Freeport*	--	6
Clay and covered	5	--
Sandstone, shaly	4	--
Sandstone	29	--
Covered	5	--
Coal blossom, *Middle Kittanning*	3	--
Sandstone	37	--
Coal blossom, *Lower Kittanning*	1	6
Clay	1	--

In Perry Township, small quantities of Lower Freeport coal are mined to supply local needs. The bed here often has sufficient thickness for regular drift mining, but the coal is very hard and is difficult to work. On Little Ice Creek, north of Sheridan on the property of W. J. Graham, the bed has the following structure:

		Ft.	In.
Shale		3	--
Coal	*Lower Freeport*	--	9
Shale		--	2
Coal		2	2
Clay		1	--

Under heavy cover at this place, the coal is reported to be 2 feet 9 inches in thickness, and to be in one block without a parting. On this stream, near the road that leads to Sheridan this coal has been mined by stripping, and is reported to be 3 feet in thickness. On Lick Creek, 1½ miles east of Sheridan, the Lower Freeport coal is mined by drifting on the land of Fred Wineka, where the following record was secured:

		Ft.	In.
Shale		4	--
Coal	*Lower Freeport*	--	11
Shale		--	2
Coal		2	7
Clay, siliceous		1	--

In Fayette Township, the Lower Freeport coal has furnished a small quantity of house fuel. The productive areas are small and confined to the southwestern part of the township. Near the head of Williams Run this coal is exposed at places along the banks of the stream, and is from 1 foot to 1 foot 6 inches in thickness. On Salliday

Creek, on the property of D. H. Davidson, the bed has been mined in a small way and is reported to be about 4 feet in thickness. East of the Kenova bridge, on the property of Benjamin Davidson, the Lower Freeport coal is regularly mined by drifting. The following record was taken well under cover:

		Ft.	In.
Shale		4	--
Coal, hard, cannel nature	*Lower Freeport*	--	8
Coal		1	8
Clay		3	--

The bed is somewhat variable in thickness and in composition. In places in the mine it is reported to expand to 3 feet in thickness. Just west of the bridge this coal has also been worked and is reported to measure from 2 to 4 feet.

Economic Value

The Lower Freeport coal adds but little to the mineral resources of Lawrence County, but it has a value, however, for supplying domestic needs in a few localities, especially in Perry and Fayette townships. It is a hard, dense, oily coal often approaching a true cannel coal in appearance. It burns with a long flame and has fair heating value. The ash and sulphur are not excessive, but the former clinkers at high temperatures. Its main importance is for local use. The associated clay is usually thin and siliceous; hence it increases the value of the coal but little. However, the shales above the coal in many places have ceramic value.

UPPER FREEPORT, WATERLOO, OR No. 7 COAL

Stratigraphy and Extent

Usually the Upper Freeport coal is found from 35 to 45 feet above the Lower Freeport coal, or from 70 to 90 feet above the Middle Kittanning or Sheridan bed. Its position is below the Mahoning sandstone, which is not persistent in Lawrence County. In some localities the coal lies directly below this member, while in other places shales intervene between the coal and sandstone. In a few localities the sandstone replaces the coal completely. On the Ohio River the horizon of the Upper Freeport coal passes below cover east of North Kenova, on Little Ice Creek, near the eastern line of Perry Township, and on Ice Creek, near the village of Rock Camp. The bed, however, is above cover on Dog Fork, well towards its headwaters. North of this the Upper Freeport coal disappears east of Symmes Creek from Marion to the northern boundary of the county. On the west, small outliers are found on the tops of the hills close to the Detroit, Toledo & Ironton Railway from Ironton to Center Station, and from there north the western boundaries of Decatur and Washington townships are practically the western boundary of the outcrop of the Upper Freeport coal. The Upper Freeport coal is above drainage in practically all of Symmes and Aid townships, in southern Fayette, in western Perry and Lawrence, in eastern Upper, Elizabeth, Decatur, and Washington, and in northwestern Mason. The Upper Freeport coal is not persistent, but is developed only in pockets, the best of which are in the Symmes Creek basin. It has been mined for years for local use near Waterloo; consequently it is generally known in Lawrence County as the Waterloo coal. The best of these pockets that have been worked or prospected will be given. See Map VII.

Fayette Township.—The horizon of the Upper Freeport coal is marked by red clays with a smut streak, or by a thin impure layer of coal in places along Salliday Creek and along the base of the Ohio River hills near North Kenova, in Fayette Township. No coal of value was observed.

Perry Township.—The Upper Freeport coal expands so that it is mined in local areas in Perry Township. The deposits are somewhat thin, but the coal is of good quality. On Little Ice Creek the Upper Freeport coal seldom thickens to over 1 foot, and the usual measurement is less than this. North of this stream, on Ice Creek, near the mouth of Turkey Fork, the bed has sufficient volume in a small area for drift mining. The record obtained follows:

	Ft.	In.
Sandstone	18	--
Clay and shale	1	10
Coal, *Upper Freeport*	2	1
Covered	80	--
Coal, *Middle Kittanning*	1	--

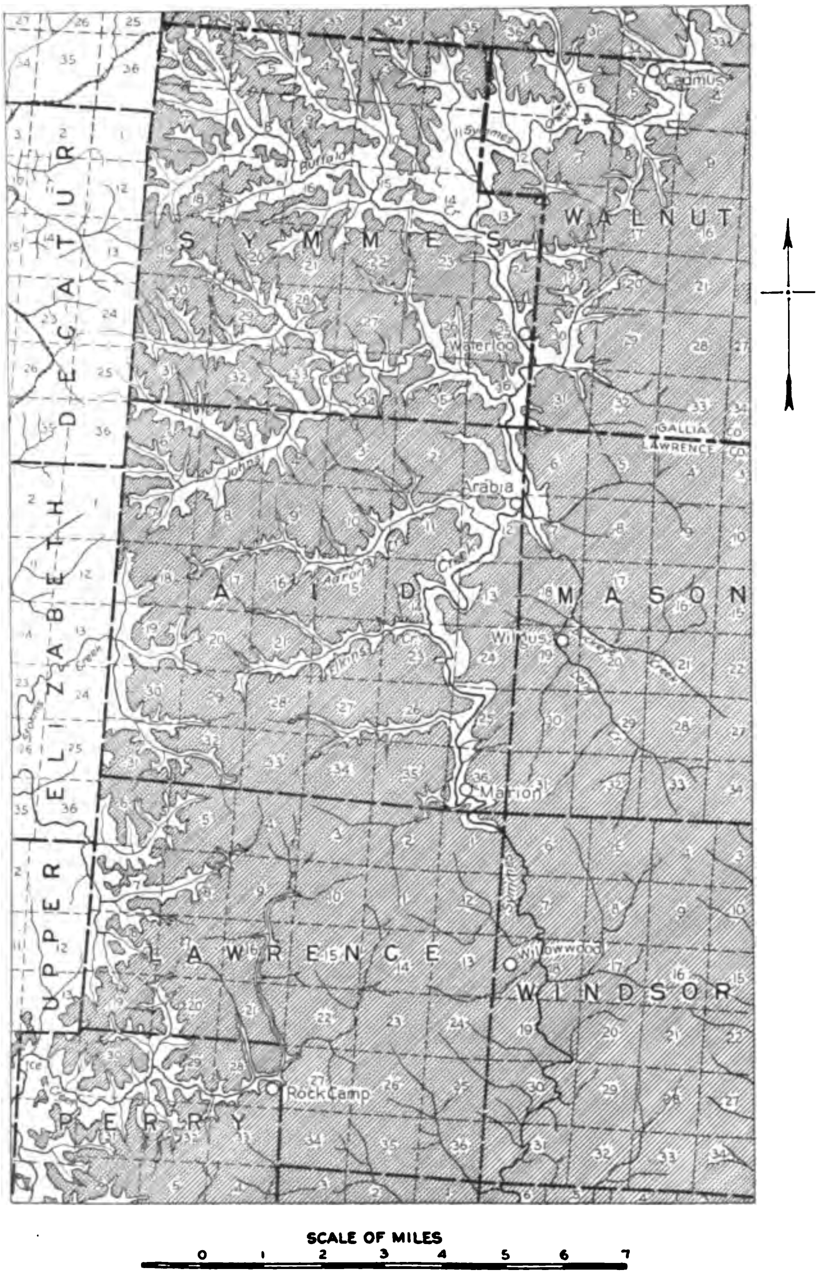
On Ice Creek, one mile west of Rock Camp, the Upper Freeport coal has been opened and worked, but no mines were in operation when the locality was visited in 1912. J. R. Bowman reports that the bed varies in thickness from 1 foot 6 inches to 2 feet 6 inches, and in some places carries a bony parting. A characteristic section reported by him is as follows:

		Ft.	In.
Shale		3	--
Clay shale, often wanting		--	6
Coal	*Upper Freeport*	1	6
Bone coal		--	6
Coal		--	10
Clay		2	--

The bone layer is wanting in places.

In the vicinity of Rock Camp the Upper Freeport coal was worked for years, although not mined at present. H. S. Brammer reports that the coal is in a solid block about 2 feet thick, and has a clay or shale between it and the overlying sandstone. There is a considerable area of unworked coal in this vicinity.

MAP VII.



Upper Freeport or No. 7 Coal in the Waterloo Field of Lawrence and Gallia counties.

Lawrence Township.—In Lawrence Township the Upper Freeport coal is above drainage along Dog Fork, along the headwaters of Turkey Fork, and along the tributaries of Storms Creek, that rise in the western part of the area. The workable coal is confined to small pockets, the best of which will be considered. The Upper Freeport coal has been opened and worked near the head of Turkey Fork just south of Kitts Hill, in Lawrence Township. The section is as follows:

	Ft.	In.
Clay shale, with thin coal bands	5	--
Coal, *Upper Freeport*	2	2
Clay	2	--

Not far from the head of the stream, one-half mile north of Kitts Hill, near the western edge of Lawrence Township, where the Upper Freeport coal goes under cover, it has been benched in the creek bottom. Pleasant Webb reports the coal as follows:

	Ft.	In.
Sandstone, massive	10	--
Clay	2	6
Coal, *Upper Freeport*	1	6

On the next stream north of this the coal has been worked to a small extent, and near the head of the stream the following section was taken in a cave:

		Ft.	In.
Shale		--	4
Coal, bony	*Upper Freeport*	--	6
Clay		--	4
Coal		2	2
Clay		1	--

It has also been mined by benching from the bed of the stream. The Upper Freeport coal is above drainage for one and one-half miles up Ned Fork, in Perry and Lawrence townships, but where seen it is only a few inches in thickness. No mines have been opened on this creek. On Dog Fork, however, near the Marion Road, in Lawrence Township, it is worked at present. On the property of E. L. Willis the following section was taken:

		Ft.	In.
Clay or shale, not regular		1	1
Coal, not regular	*Upper Freeport*	--	8
Shale		--	3
Coal		--	8
Coal, bony		--	4
Clay		--	4
Coal		2	8
Clay		2	--

Where the 11 inches of coal and shale are present the clay and shale above thin. The lower bench of coal varies from 2 feet to 2 feet 8 inches in thickness. Mr. Willis reports that the bed holds its thickness well as far as it has been tested. One-half mile north of this it is being mined at the level of the Marion road, where the section is as follows:

		Ft.	In.
Sandstone		10	--
Shale		3	--
Coal, good	*Upper Freeport*	--	8
Coal, bony		--	6
Clay shale		--	4
Coal		2	2
Shale, with thin coal bands		--	6

A section measured in another entry about 50 feet away gave the following:

		Ft.	In.
Sandstone		15	--
Shale, gray		1	1
Clay, dark		1	4
Coal, good	*Upper Freeport*	--	9
Shale		--	1
Coal, bony		--	8
Clay shale		--	4
Coal		2	3
Clay		2	--

On the property of George Steele, one-half mile farther south, a section taken in an entry is as given below:

		Ft.	In.
Shaly sandstone		10	--
Clay shale		2	6
Coal, bony, not taken down	*Upper Freeport*	--	8
Clay, good quality		1	--
Coal		2	4
Clay, seen		2	--

Mr. Steele reports that the bed holds its thickness well as far as prospected under cover.

Upper, Elizabeth, and Decatur Townships.—The horizon of the Upper Freeport coal is found in the eastern parts of all these townships, but the member is not represented by coal in any considerable thickness. No deposits that may be mined by drifting were noted.

Aid Township.—In local areas in Aid Township the Upper Freeport coal has excellent volume, and regularly contributes most of the local fuel supply. The best of the coal areas are located on Sharps Creek near Cherryville, on Symmes Creek near Marion, and on Elkins Creek near Oak Ridge Furnace. Near Manker the Upper Freeport coal was seen in the bed of the creek, and was represented by a thin stain and 4 feet of clay. About one-half mile north of here, on the property of

Henry Harth, it is opened, and near the outcrop shows 2 feet 2 inches of coal, with 4 inches of parting.

On the east side of Symmes Creek in Aid Township, one mile north of Marion, it has been opened and worked on the Edward Russel farm. The banks had fallen, but Mr. Russel reports the section as below:

		Ft.	In.
Sandstone		10	--
Coal, somewhat bony	*Upper Freeport*	2	6
Shale, hard		1	--
Coal, solid block		4	6
Clay		2	--

The upper bench is usually left for a roof. Near the bridge over Symmes Creek, north of Marion, on the property of Charles Russel, the following section was taken:

		Ft.	In.
Sandstone		6	--
Shale, soft, jointed, bad roof		3	--
Coal, somewhat bony	*Upper Freeport*	1	--
Clay shale		--	4
Coal		3	4
Clay		1	--

On the west side of Symmes Creek, just south of the bridge, the coal has been mined for years. A section measured in the mine of Calvin Haskins is as follows:

		Ft.	In.
Shale		10	--
Coal, bony, not taken down	*Upper Freeport*	--	5
Shale, with thin coal bands		--	8
Coal		3	2
Clay		2	--

Mr. Haskins reports that the lower bench holds its thickness well and averages about 3 feet 2 inches. The upper 5 inches of coal is somewhat bony, so that it is left to form a roof. The coal is used for local domestic purposes. On Sharps Creek, near Cherryville, there is a well developed pocket of Upper Freeport coal. It has been mined for local use, but no mines were open in 1912. Wm. M. Nance reports the section as follows:

		Ft.	In.
Clay shale and shale		4	--
Coal	*Upper Freeport*	2	6
Shale		--	3
Coal		3	--
Clay		2	--

He also states that the coal thins on going into the hill. On Sharps

Creek, the Upper Freeport coal has a thickness of 5 feet 9 inches, all told, and its structure is shown below:[1]

		Ft.	In.
Sandy shale		2	--
Coal	*Upper Freeport*	1	6
Bone coal		--	1
Coal		--	8
Clay		--	2-3
Coal		3	3
Clay		1	--

On Elkins Creek, near Oak Ridge Furnace and on the largest northern tributary, Barnett Creek, it has been mined in a small way for years. A section taken in the Wm. Hoover mine, near Oak Ridge Furnace, is as follows:

		Ft.	In.
Sandstone		60	--
Black shaly coal		--	6
Coal, generally good	*Upper Freeport*	1	7
Clay		--	7
Coal		2	4
Clay		2	--

The upper bench of coal here is reported by Mr. Hoover to have some bone coal in it in places, but generally it is good. Up Barnett Creek, where the bed has also been mined, the lower bench of coal is reported to be 3 feet thick. On Symmes Creek, about one mile north of the mouth of Elkins Creek on the land of Joseph Howard, a small mine has been worked. Mr. Howard reports the coal only 1 foot 6 inches in thickness. About a mile southeast of Arabia, on Long Creek in Mason Township, where the Upper Freeport coal goes under cover, J. C. Neal reports the bed as below:

	Ft.	In.
Sandstone	10	--
Shale, with thin coal bands	3	--
Coal, *Upper Freeport*	2	--
Clay	2	--

On Aaron Creek, in Aid Township, south of Tipton Knob, the Upper Freeport coal is again well developed, and some small mines have been worked for a local coal supply. S. D. Griffith reports the coal on his property as follows:

		Ft.	In.
Coal, somewhat bony	*Upper Freeport*	2	--
Shale		--	4
Coal		3	6

Mr. Griffith states that the lower coal bench varies from 3 to 4 feet. Near the head of the stream, south of Tipton Knob, it has been opened. No banks were being operated in 1912, but the bed is reported to be from 3 to 4 feet in thickness. Near the head of the stream, east of Tipton Knob, W. M. Herell reports the lower block of the Upper Freeport coal on his property to be 4 feet thick. On Symmes Creek, from Arabia to Waterloo, the coal is thin where seen, and no banks have been opened.

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[1] Geol. Surv. of Ohio, Vol. 5, p. 1056.

Symmes Township.—Some areas in which the Upper Freeport coal has excellent volume and purity are found in Symmes Township. The best of the field of this coal in southern Ohio is near Waterloo, in Gallia County. The areas in which the member has workable thickness will be discussed. On Johns Creek, east of Sherritts in Symmes Township, the Upper Freeport coal has been worked for years on the property of A. T. Pyles. No banks were being operated when the locality was visited in 1912. Mr. Pyles reports that the coal is in only 1 bench here and will average 3 feet 6 inches in thickness with a maximum of 4 feet 7 inches. The coal is of good quality.

About 1 mile west of Waterloo, on the first small tributary to Johns Creek, the Upper Freeport coal has been opened and worked somewhat for local use. A section taken here is as follows:

	Ft.	In.
Sandstone	25	--
Clay shale, soft	1	1
Coal, *Upper Freeport*	3	2
Clay	1	--

Farther west on Johns Creek the blossom of this coal, only a few inches thick, was observed in a number of places, but no banks were found. On Buckeye Fork, the blossom of the coal observed in a number of places indicates that the bed is thin in this locality, which is also the case on North and Slab forks.

The Upper Freeport coal is well developed east of Waterloo in Gallia County, where it has been worked for many years to furnish the local fuel supply for Waterloo and vicinity. A section taken in the mine of John Strait, near the Lawrence County line, is as follows:

		Ft.	In.
Shale		6	--
Coal, somewhat bony	*Upper Freeport*	1	3
Clay		--	9
Coal		3	6
Clay		2	--

On the property of T. H. Neal, on Symmes Creek near the mouth of Buffalo, the Symmes Valley Coal Company drove an entry through the hill in which the next section was measured:

		Ft.	In.
Sandstone, massive		8	--
Shale, draw slate		--	4
Coal	*Upper Freeport*	--	6
Clay shale		1	1
Coal		3	2
Clay		2	--

On Buffalo Creek, the Upper Freeport coal is thin except in a few places. John Rehmer reports it on his property as follows:

		Ft.	In.
Shale		2	--
Draw slate		--	8
Coal	*Upper Freeport*	--	8
Shale		--	2
Coal		1	6
Clay		1	--

M. V. Thompson reports a pocket of Upper Freeport coal on Caulley Creek, which shows on the outcrop from 3 feet to 3 feet 6 inches in thickness. At the head of the first southern tributary of Buffalo Creek, H. W. Steward states that the Upper Freeport coal is about 4 feet thick on the outcrop.

Washington Township.—The Upper Freeport horizon is present near the summits of the main ridges in eastern Washington Township, but it is marked by only a thin stratum of coal, when marked at all. At no place was coal of value found. In the Cincinnati, Hamilton & Dayton Railway tunnel near Hoadley, the Upper Freeport coal is exposed and it varies from a stain to 12 inches in thickness.

The Upper Freeport coal is invariably thin along its most western exposures, but thickens generally to the east. The most western pocket of any considerable thickness is on the headwaters of the tributary of Storms Creek northwest of Kitts Hill in the northwestern corner of Lawrence Township. Thus the sections indicate that there is a belt in which the coal is somewhat continuous and regular, commencing south in the vicinity of Rock Camp and Kitts Hill, and extending northward across Sharp Creek near Cherryville, Elkins Creek near Oak Ridge Furnace, Aaron Creek east of Tipton Knob, Johns Creek near Sherritts, and striking Symmes Creek in the Waterloo region.

The sections further indicate that there is another belt from the Marion pocket extending northward across the mouth of Long Creek east of Arabia. The deposit on Buffalo and Caulley creeks seems to be a small outlying pocket. Prospecting by the drill in this part of the field should be done north and south along these belts. As the bed generally thickens eastward, and as it is well developed where it goes under cover near Marion, Arabia, and east of Waterloo, it is reasonable to think that at least there are other pockets of good coal under heavy cover. If the thin and pockety condition of the bed in the western part of the field represents the edge of the coal basin, then the best of the field should be eastward under heavy cover. The prospects at least warrant some testing with the drill.

Economic Value

The hills in the Symmes Creek basin are considerably broken by slips, which throw the coal on the outcrop out of position, and which cause trouble in driving entries. Breaks were noticed in several mines.

The coal in the localities where it is or has been worked is generally sufficiently thick for ease in mining, in fact, the maximum thickness of this bed far exceeds that of any other coal found in the county. Thicknesses of from 4 to 6 feet for the entire deposit are quite common.

The sections show that in most of the field the bed is broken into several benches of coal, with clay or shale intervening. These partings increase the cost of mining as they must be removed from the mine or gobbed, and as they also decrease the value of the coal for more or less of these materials are loaded with it. In many of the mines the roof is bad, as it is a clay, or clay shale, or a soft jointed shale, which falls unless well posted. In some of the mines the shale between the coal and sandstone above is thin, and it soon loosens and falls. Circulating waters descend through the porous sandstone above to the more impervious shale, which loosens from the sandstone. In some localities the Mahoning sandstone forms the roof, and it often extends down to the main bench of coal, or occasionally replaces the entire bed. In some of the mines the upper layers of coal, which are somewhat bony, are left, as they make a much better roof than the soft shale or clay. The floor is clay or clay shales. In some localities this clay is of fair quality and may be used for ceramic products. The floors of the mines are usually irregular, owing to a change in the thickness of the lower coal bench, and also to rolls in the underlying beds. The mining conditions are not ideal on account of the character of the roof materials, of the structure of the bed, which is composed usually of several benches of coal with partings intervening, of the uncertainty in the thickness of the deposit, and of the variable quality of the coal in the upper benches. The territory should be thoroughly tested with the core drill before any large mining operations are installed. The coal in the lower bench is invariably of excellent quality, while that in the next bench is usually of a much inferior grade, owing to its bony nature and high ash content. The thin upper benches, where present, are good block coals. The marketable coal is found in the lower and upper benches. Where a plant is mining coal for its own use the fuel from the entire deposit may be utilized successfully. The quality of the coal, and the section from which the sample was taken, is given in the following:[1]

Sample and section from Cooper's mine, section 24 or 25, Symmes Township Lawrence County. Sample was taken from lower bench only. Good sample. Taken by E. E. Somermeier, in August, 1901.

Section of coal

	Ft.	In.
Clay and shale.		
Coal, upper bench	1	3
Clay	--	5
Coal	--	3
Shale	--	7
Coal, lower bench	4	--

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[1] Geol. Surv. of Ohio, Fourth Series, Bull. 9, p. 250.

Chemical analysis and calorific value

Ultimate		*Proximate*	
Carbon	67.09	Moisture	7.13
Hydrogen	5.33	Volatile matter	33.65
Oxygen	16.08	Fixed carbon	50.31
Nitrogen	1.28	Ash	8.91
Sulphur	1.31		
Ash	8.91		

Calorific value { 6,716 calories.
12,089 B. t. u.

Sample and section of mine of G. W. Peach, section 23, Symmes Township, Lawrence County. Sample includes both benches. Sampled by E. E. Somermeier, in August, 1901.[1]

Section of coal

	Ft.	In.
Coal, upper bench	--	5
Clay	1	2
Coal, lower bench	3	9

Chemical analysis and calorific value

Ultimate		*Proximate*	
Carbon	66.88	Moisture	8.77
Hydrogen	5.32	Volatile matter	31.70
Oxygen	17.08	Fixed carbon	50.82
Nitrogen	1.25	Ash	8.71
Sulphur	.76		
Ash	8.71		

Calorific value { 6,585 calories.
11,853 B. t. u.

Sample and section of mine of William Sneed, section 26 or 27, Symmes Township, Lawrence County. One bench only sampled, that being the only part mined. Fresh face of coal. Sampled by E. E. Somermeier, in August, 1901.[2]

Section of coal

	Ft.	In.
Shale.		
Coal	3	2
Clay.		

Chemical analysis and calorific value

Ultimate		*Proximate*	
Carbon	64.90	Moisture	8.38
Hydrogen	5.18	Volatile matter	31.45
Oxygen	16.72	Fixed carbon	50.08
Nitrogen	1.27	Ash	10.09
Sulphur	1.84		
Ash	10.09		

Calorific value { 6,497 calories.
11,695 B. t. u.

Sample and section of Walter Rose Mine, section 21, Aid Township, Lawrence

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[1] Geol. Surv. of Ohio, Fourth Series, Bull. 9, p. 251. [2] *Ibid*, p. 253.

County. Good sample of lower bench, the upper bench not mined. Sample cut by E. E. Somermeier, in August, 1901.[1]

Section of coal

	Ft.	In.
Coal, upper bench	1	4
Clay	--	7
Coal, lower bench	2	6

Chemical analysis and calorific value

Ultimate		*Proximate*	
Carbon	63.03	Moisture	7.85
Hydrogen	5.09	Volatile matter	32.90
Oxygen	15.79	Fixed carbon	47.07
Nitrogen	1.25	Ash	12.18
Sulphur	2.66		
Ash	12.18		

Calorific value { 6,305 calories. 11,349 B. t. u.

Sample and section of Haskin's mine section 36, Aid Township, Lawrence County. Sample taken from lower bench only, the upper bench not mined. Sampled by E. E. Somermeier in August, 1901.[2]

Section of coal

	Ft.	In.
Coal, upper bench, not mined	1	--
Shale, very hard	1	--
Coal, lower bench	3	2
Fire clay.		

Chemical analysis and calorific value

Ultimate		*Proximate*	
Carbon	66.94	Moisture	8.37
Hydrogen	5.21	Volatile matter	31.80
Oxygen	17.02	Fixed carbon	51.60
Nitrogen	1.31	Ash	8.23
Sulphur	1.29		
Ash	8.23		

Calorific value { 6,596 calories. 11,873 B. t. u.

Sample and section of mine of Thomas Bennètt, section 35, Aid Township, Lawrence County. Both benches included in the sample. Sampled by E. E. Somermeier, in August, 1901.[3]

Section of coal

	Ft.	In.
Shale.		
Coal, upper bench	1	--
Shale	--	1½
Coal, lower bench	3	--
Fire clay.		

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[1] Geol. Surv. of Ohio, Fourth Series, Bull. 9, pp. 253-4.

[2] *Ibid*, p. 254.

[3] *Ibid*, pp. 255-6.

Chemical analysis and calorific value

Ultimate		*Proximate*	
Carbon	65.20	Moisture	8.45
Hydrogen	5.10	Volatile matter	31.25
Oxygen	16.21	Fixed carbon	49.02
Nitrogen	1.28	Ash	11.28
Sulphur	.93		
Ash	11.28		

Calorific value { 6,405 calories. 11,529 B. t. u.

Sample and section of mine of Frank Kitts, section 16, Lawrence Township, Lawrence County. Lower bench only sampled, the upper one not worked. Sampled by E. E. Somermeier, in August, 1901.[1]

Section of coal

	Ft.	In.
Sandstone and shale.		
Coal, upper bench, not mined	1	2
Clay	--	7
Coal, lower bench	2	2
Fire clay.		

Chemical analysis and calorific value

Ultimate		*Proximate*	
Carbon	65.03	Moisture	7.20
Hydrogen	5.03	Volatile matter	32.25
Oxygen	15.69	Fixed carbon	49.88
Nitrogen	1.25	Ash	10.67
Sulphur	2.33		
Ash	10.67		

Calorific value { 6,556 calories. 11,801 B. t. u.

The average of the above seven analyses is as follows:

Ultimate		*Proximate*	
Carbon	65.58	Moisture	8.02
Hydrogen	5.18	Volatile matter	32.14
Oxygen	16.37	Fixed carbon	49.83
Nitrogen	1.27	Ash	10.01
Sulphur	1.59		
Ash	10.01		

Calorific value { 6,523 calories. 11,741 B. t. u.

The average calorific value, 6,523 calories, or 11,741 B. t. u., of the Upper Freeport coal in Lawrence County is somewhat low, thus giving it a rather poor rating if sold on the heat unit basis in competition with the Pocahontas coal of West Virginia. It is only a medium free-burning coal, and has a short flame. The ash, which is about on the average with other Ohio coals, does not clinker, but goes to a light powder. It is a tender fuel and would not ship well, as the lumps break easily in handling. The coal has a good bright luster, and that in the lower bench is usually quite free from pyrite. The average sulphur, 1.59 per cent, is lower than for any other bed in the county. It is a coking coal, but has not been used for this purpose in Ohio, although it is coked in western Pennsylvania, and produces a fair product.

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[1] Geol. Surv. of Ohio, Fourth Series, Bull. 9, p. 256.

The average sulphur content of the seven samples of the Upper Freeport coal in Lawrence County is 1.59 per cent, of which about one-half is lost during the process of coking. This will put the sulphur within the limit of cokes now used, but it will still be above the standard, which is 1.00 per cent. The average ash is 10.01 per cent, which is high for a coking coal. In the retort oven the yield of coke will be about as follows:

	Composition of coal	Parts to coke	Composition of coke
Moisture	8.02	------	------
Volatile matter	32.14	1.00	1.65
Fixed carbon	49.83	49.83	81.90
Ash	10.01	10.01	16.45
	100.00	60.84	100.00
Sulphur	1.59	.80	1.31

During coking part of the heavy gaseous compounds are broken up with deposition of carbon, the latter amounting to about 1 per cent. The ash and sulphur, both of which can be considerably lowered by proper care in mining and washing, are too high for marketable coke. The average of the three samples from Cooper, Peach and Haskin's mines is as given below:

	Composition of coal	Parts to coke	Composition of coke
Moisture	8.09	-----	------
Volatile matter	32.38	1.00	1.65
Fixed carbon	50.91	50.91	84.11
Ash	8.62	8.62	14.24
Sulphur	1.12	.56	.93

This sulphur, .93 per cent, is within the limit, but the ash is still high. A mixture of the Upper Freeport coal with Pocahontas would increase the yield considerably, and lower the sulphur and ash content. The analysis of Pocahontas coal averages about as follows:[1]

Moisture	1.16
Volatile matter	20.76
Fixed carbon	74.90
Ash	3.18
Sulphur	.61

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[1] U. S. Bureau of Mines, Bull. 1, pp. 25-26.

In the retort oven the yield from Upper Freeport coal for the average of the three samples given would be approximately as follows:

Coke	60.53 per cent.
Tar	11 gallons per ton coal.
Ammonium sulphate	24 pounds per ton coal.
Total gas	8,000 cubic feet per ton coal.

The yield in the retort oven from Pocahontas coal is given by Porter and Ovitz as follows:

Coke	79.1 per cent
Tar	7.2 per cent, which equal 14.4 gallons per ton coal.
Ammonium sulphate	12.9 pounds per ton coal.
Total gas	9,700 cubic feet per ton coal.

About one-half the sulphur content of the coal is lost in coking and about 55 per cent of the total gas is used in the ovens for fuel.

A mixture of equal parts of Upper Freeport and Pocahontas coals would yield in the retort oven as follows:

Kind of coal.	Yield of coke in per cent.	Sulphur in coke in per cent.	Ash in coke in per cent.	Tar in gallons per ton coal.	Ammonium sulphate in pounds per ton coal.	Total gas per ton coal.	Excess gas per ton coal —45 per cent of total.
Upper Freeport	60.53	.56	8.62	11.0	24.00	8,000	3,600
Pocahontas	79.10	.305	3.18	14.4	12.90	9,700	4,365
One-half of above sum	69.815	.4325	5.90	12.7	18.45	8,850	3,983

The composition of the coke is as follows:

Carbon	91.55 per cent
Ash	8.45 per cent
	100.00 per cent
Sulphur	.62 per cent

This gives a coke well within the limits demanded for metallurgical uses.

CONEMAUGH FORMATION

The Conemaugh formation, formerly known as the Lower Barren Coal Measures, includes the rocks in the interval from the Upper Freeport to the Pittsburgh coal. These rocks are mainly massive sandstones, highly ferruginous and calcareous shales and clays, and occasional thin limestones and coals. The limestones are variable in composition and uncertain in extent, as they are often replaced by other rocks. With the exception of the Wilgus coal, which is quite persistent and of local importance, the beds in Lawrence County are thin and of little value. The western boundary of the Conemaugh formation is marked by the limit of the Upper Freeport coal, which in a general way is the Detroit, Toledo & Ironton Railway from Ironton to Center Station, thence westward to the western part of Decatur and Elizabeth townships. Along this boundary the Conemaugh rocks cap only the highest hills, but eastward the dip is such that the Mahoning sandstone, which is the lowest member of the Conemaugh, is just above drainage on Ice Creek near Rock Camp, on Dog Fork, and on Symmes Creek from Marion north of the Lawrence-Gallia county line. In the eastern part of the county the Monongahela formation appears and caps the hills and ridges.

The Conemaugh formation is characterized by the shales and clays which are highly colored, owing to the impregnation of iron oxides, and which are rich in lime that occurs both in the highly disseminated and nodular forms. The phosphoric acid content is also far above that ordinarily found in clays or shales.

General Section in Lawrence County[1]

	Conemaugh formation.		Ft.	In.
26.	Clay, with a little nodular limestone		3	--
25.	Shale, sandy, and thin-bedded sandstone		37	--
24.	Sandstone, *Connellsville*, coarse-grained, massive		30	--
23.	Coal streak.			
22.	Shale		18	--
21.	Sandstone, shaly to massive		20	--
20.	Clay shale, red		20	--
19.	Limestone, nodular		1	--
18.	Shale, sandy		8	--
17.	Sandstone		30	--
16.	Shale		12	--
15.	Clay shale, red, having nodules of limestone and hematite. Replaced by shaly sandstone in some localities		36	--
14.	Limestone, *Portersville*, impure, fossiliferous		--	8
13.	Coal, *Anderson*, thin.			
12.	Clay shale		37	--
11.	Limestone, *Cambridge*, fossiliferous, missing in some localities		2	--
10.	Shale, carbonaceous		2	--
9.	Coal, *Wilgus*		2	--
8.	Clay, shale		17	--
7.	*Brush Creek* horizon	Limestone, impure, fossiliferous, cherty in many places	2	--
		Shale	14	--
		Limestone, impure, fossiliferous. Frequently missing	1	6
6.	Shale, sandy, and flaggy sandstone		23	--
5.	Coal, *Mason*, thin.			
4.	Clay, pale red		8	--
3.	Sandstone, shaly		15	--
2.	Coal, *Mahoning*, thin.			
1.	Sandstone, *Mahoning*		24	--

Upper Freeport or "Waterloo" coal. Top member of *Allegheny* formation.

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[1] Geol. Survey of Ohio, Bull. 17, p. 63.

BRUSH CREEK LIMESTONE

Stratigraphy and Extent

This limestone, when present, is found usually from 80 to 90 feet above the Upper Freeport coal, and from 20 to 30 feet below the Cambridge limestone. In parts of Gallia County, where characteristically developed, there are two beds of this member, which are separated by 15 to 20 feet of shale. As the Brush Creek limestone extends southward into Lawrence County, the separate limestone beds become less distinct, and the whole interval in places is taken by thin layers of flinty limestone interbedded with shales. The member is best represented in Symmes, Aid, Mason, and Lawrence townships, but it is also found in local areas in Decatur, Elizabeth, Perry, and Windsor. Some of the best developed exposures noted will be described in the next few pages.

South of Aaron Creek in Aid Township, the Brush Creek limestone is usually wanting, as it is replaced by a heavy sandstone. In the bed of Ice Creek, near Andis in Lawrence Township, it is represented by about 2 feet of flinty limestone; while thin siliceous layers were noted on the outcrop in a few other adjacent localities. On the ridge south of the head of Aaron Creek in Aid Township, a few feet of Brush Creek limestone are found, while on the ridge between Aaron and Johns creeks, the limestone is well developed and persistent. Near Tipton's Knob a section taken is as follows:

		Ft.	In.
Limestone, *Cambridge*		2	--
Shales and covered		23	--
Limestone	*Brush Creek*	--	5
Parting.			
Limestone		--	6
Shale		--	1
Limestone		--	8
Shale		--	1
Limestone		--	11
Parting.			
Limestone			3
Parting.		--	
Limestone		--	6
Shale		--	3
Limestone		--	6
Shale		--	2
Limestone		--	5
Parting.			
Limestone		1	5
Shale		1	3
Limestone		1	4

East of Tipton Knob in Aid Township, the Brush Creek limestone thins, and on the hills near Symmes Creek, it is wanting or represented by a foot or two of siliceous limestone. West of Tipton Knob, it is well developed on the ridge between Aaron and Johns creeks to their heads, and then in eastern Elizabeth and Decatur townships on the ridge between these streams and Storms and Cannons creeks. East of Arabia in Mason Township on Buck Creek, the deposit is again quite thick. A section was taken along the road that goes from Buck Creek to Pigeon Creek, and it shows the structure of the Brush Creek limestone as follows:

	Ft.	In.
Limestone, flinty	--	10
Shale	--	1
Limestone, flinty	--	4
Parting.		
Limestone, flinty	--	8
Shale	--	2
Limestone, flinty	--	4
Shale	--	6
Limestone, flinty	--	6
Shale	--	4
Limestone, flinty	--	4
Shale	--	6
Limestone, 6 thin layers	2	10
Shale, greenish tint	--	9
Limestone	--	3
Shale, greenish tint	--	5
Limestone	2	6
Shale with nodular limestone	1	2
Greenish shale with 3 thin nodular layers of limestone	1	3
Shale, blue	1	--

On Johns Creek, on the knob west of Sherritts in Symmes Township, the stone has been quarried for road use. A section taken in the quarry is as follows:

	Ft.	In.
Soil.		
Limestone	2	--
Shale	--	1
Limestone	1	--
Shale	--	1
Limestone	--	11
Shale	--	4
Limestone	--	6
Shale	--	5
Limestone	--	4
Shale	--	2
Limestone, flinty, with thin irregular mud planes	3	2

In Symmes Township, on the ridge between Johns and Buffalo creeks north of Sherritts, the Brush Creek limestone is heavy, but it thins eastward towards Symmes Creek, where it is only from 1 to 5 feet in thickness. In the region around Stewart Knob it is also thin or wanting, but on the ridge in Decatur Township, east of the tunnel on the Cincinnati, Hamilton & Dayton Railway north of Dean, it is again well developed, and the bed at one exposure measured 8 feet in thickness. On the highest knobs on the ridge westward from the tunnel to Poplar Flats, the member is exposed and at the latter place this deposit, the most western noted in Lawrence County, where it caps the highest point, is several feet in thickness.

Near the top of the divide from Slab Fork to Pine Creek in Decatur Township, 6 feet of flinty Brush Creek limestone are exposed in the road. It is also found on the ridge at the head of North and Buckeye forks along the Symmes-Decatur township line, where it is several feet in thickness. There are a few feet of Brush Creek limestone on Phillips Knob, but on the ridge north of this, it thins down to a foot or two or is wanting. The member was not seen in any considerable thickness in Symmes Township north of Buffalo Creek.

Economic Value

The Brush Creek limestone is of little importance economically, as it is very siliceous and in many cases practically flint. It is far too impure for metallurgical use or land dressing and about all the value it has is for building roads in the localities in which it occurs. For this purpose the quality of the limestone is considered much inferior to either the Cambridge or the Ferriferous. Owing to its brittle flinty nature it is lacking in toughness, which is required in materials subjected to abrasive strains. It is used to good advantage in road building for the foundation, where a better grade of stone is added for the facing.

Wilgus Coal and Cambridge Limestone

The next members of importance are the Wilgus coal and the Cambridge limestone, which have only a local value, the coal for domestic use and the limestone for road purposes. Both are quite persistent, but usually thin. They are best developed near Wilgus, in Mason Township, near Arabia in Aid, and on the ridge north of Sherritts in Symmes. These beds are found with less volume, or with less areal extent, also in Decatur, Washington, Elizabeth, Lawrence, Perry, Fayette, Windsor, and Union townships. The Wilgus coal lies either directly or only a few feet below the Cambridge limestone, the position of which is about 20 feet above the Brush Creek limestone and about 80 feet below the Ames, although the latter is seldom present in Lawrence County. These members will be hurriedly traced across the county, and their relations to each other and to various members will be shown by sections taken along the line of outcrop.

Fayette Township.—The Wilgus coal is marked in local areas in Fayette Township by a stratum of more or less impure coal, overlaid usually by shale and sandstone, while the Cambridge limestone is found only in isolated areas, and is seldom over 2 feet in thickness. On the ridge north of Salliday Creek, on the property of Samuel Stanley, the Wilgus coal has the following structure:

		Ft.	In.
Shale		5	--
Coal, bony	*Wilgus*	1	1
Coal, shaly		--	11
Coal, good		1	6
Clay, siliceous		1	--

On the Ohio River hills, near the mouth of Salliday Creek, on the land of J. B. McKee, the Wilgus coal is present, but the Cambridge limestone is replaced by a thick sandstone. The section secured follows:

		Ft.	In.
Sandstone		20	--
Coal, good	*Wilgus*	--	10
Coal, bony		3	--

Perry Township.—The Wilgus coal is quite steady in eastern Perry Township, but it is usually shaly; hence it is of small value. The Cambridge limestone was only occasionally observed, for in most of the area its place is taken by a massive sandstone. On the Ohio River hills, south of Lick Creek, the Wilgus coal has been prospected on the property of William Talbot by a short entry, where the measurements given below were taken:

		Ft.	In.
Shale		7	--
Coal, good	*Wilgus*	1	--
Shale		--	1
Coal, hard, bony		2	4
Sandstone		20	--

North of this the blossom of the Wilgus coal was noted at a number of places, but everywhere it was shaly in character. The structure reported is from 1 foot to 1 foot 6 inches of good coal, underlaid by 2 or 3 feet of bony coal. At some exposures from 1 to 2 feet of siliceous Cambridge limestone are found about 10 feet above the coal. South of Rock Camp the limestone was seen on several hills about 120 feet above the horizon of the Upper Freeport coal.

Union Township.—The Cambridge limestone, from 1 to 2 feet in thickness, and the underlying Wilgus coal, from 1 to 3 feet, are found along the Symmes Creek Valley, in the western part of Union Township. They disappear below cover about one mile from the mouth of Symmes Creek, and the coal is mined in a small way at a few places. No sections were obtained.

Lawrence Township.—Both the Wilgus coal and the Cambridge limestone are fairly constant in Lawrence Township, where the coal is mined some for domestic use, and where the limestone is quarried for road building. They extend across practically the whole of the township, but neither has any considerable value. On the property of W. J. Dilley, at Andis, the section taken in a small coal mine is as follows:

	Ft.	In.
Limestone, *Cambridge*	1	6
Coal, *Wilgus*	1	6
Clay	2	--

At the head of Dog Fork the section reported by Frank Townsend is as given below:

	Ft.	In.
Limestone, *Cambridge*	4	--
Coal, *Wilgus*	1	--

Windsor Township.—The Wilgus coal and Cambridge limestone are present along the Symmes Creek Valley, in the western part of Windsor Township. The limestone has been utilized for road making, while the coal has contributed a small quantity of house fuel. At Millville, in Windsor Township, on the property of William Holschuh, the limestone has been quarried for road use. The coal was not seen, but was reported present by Mr. Holschuh. The section is as follows:

	Ft.	In.
Limestone, *Cambridge*	3	--
Coal, *Wilgus*	1	6

On Symmes Creek, between Millville and Marion, the limestone and coal were seen in several places, but both were thin.

Aid Township.—In their extension northward from Lawrence Township into Aid both the Wilgus coal and the Cambridge limestone increase in thickness and in purity. The Cambridge bed furnishes most of the limestone used for road work, while the Wilgus member, near Arabia, reaches its maximum thickness in southern Ohio, and contributes a good part of the local fuel. North of Marion, on the property of Edward Russel, the Wilgus coal has been mined by drifting, and is reported to have the following measurements:

	Ft.	In.
Limestone, *Cambridge*	4	--
Coal, *Wilgus*	2	6

In this locality the Cambridge limestone is stated to vary from 3 to 5 feet in thickness, and the Wilgus member in places to expand to 3 feet. On the land of Charles Russel the coal has also been mined, and is reported to average about 2 feet in thickness. On the ridge south of Sharps Creek the Wilgus coal and Cambridge limestone are reported by William M. Nance to have on the average the following measurements:

	Ft.	In.
Limestone, *Cambridge*	3–5	--
Coal	1	6–8

At the head of Sharps Creek a section on the outcrop in the road shows as follows:

	Ft.	In.
Limestone, *Cambridge*	3	6
Coal, *Wilgus*	1	3
Clay	2	--

On the ridge between Sharps and Elkins creeks both coal and limestone are thin near the heads of the streams, but thicker eastward towards Symmes Creek. On the ridge south of the head of Elkins Creek a section obtained is as follows:

	Ft.	In.
Limestone, *Cambridge*	2	--
Coal, *Wilgus*	1	--

On the eastern part of the ridge Samuel Leffingwell opened a mine on his property, and reports the coal as follows:

	Ft.	In.
Limestone, *Cambridge*	6	--
Coal, *Wilgus*	3	--

On the knob south of Arabia in Aid Township, the Wilgus coal has been mined for years for local use, and the section taken under heavy cover is as follows:

	Ft.	In.
Limestone, *Cambridge*	6	--
Coal, *Wilgus*	3	3
Clay	1	--

In Aid Township, on the ridge between Elkins and Aaron creeks, both the limestone and coal were noted on the outcrop in a number of places. The limestone is from 2 to 5 feet in thickness, and the coal is reported by J. L. Ferrell to run generally from 20 to 22 inches. About one and one-half miles northwest of Arabia, on the property of A. N. Justice, the coal has been mined in a small way for 45 years. The section taken in a mine is as follows:

	Ft.	In.
Limestone, *Cambridge*	6	--
Coal, *Wilgus*	3	4

The coal has been opened in a number of places near Tipton Knob, in Aid Township. No banks in operation were seen, but W. M. Herell reports as follows:

	Ft.	In.
Limestone, *Cambridge*	--	--
Coal, *Wilgus*	3	--

West from Tipton Knob the coal thins, and at the head of Johns Creek it is only about 1 foot in thickness, but the limestone, where seen, is from 2 to 3 feet.

Mason Township.—Owing to the fact that the coal lying below the Cambridge limestone has been mined for many years for local consumption, and has excellent volume in the vicinity of Wilgus, this bed was called Wilgus coal by D. D. Condit. Both coal and limestone are found on Long and Buck creeks, and extend well towards their headwaters. In this township the limestone varies from 1 to 6 feet in thickness, while the coal expands from 1 foot to 3 feet 6 inches. The usual measurement of the latter, however, is between 2 and 3 feet.

South of Wilgus, on Long Creek, a section taken in a mine is as follows:

	Ft.	In.
Limestone, *Cambridge*	2	6
Shale	3	7
Coal, *Wilgus*	2	6
Clay	1	--

The limestone attains 5 feet in thickness in this vicinity, but the coal averages about as given above. On Buckeye Creek the thickness of the coal and that of the limestone are practically the same as on Long Creek. Near the mouth of Long Creek, on the property of J. C. Neal, the following section was taken in a new opening:

	Ft.	In.
Limestone, *Cambridge*	6	--
Coal, *Wilgus*	3	6
Clay	1	--

Both the limestone and coal are well developed on Buck Creek in northern Mason Township. Near the head of the stream, on the property of John A. Wilson, the section seen and reported is as follows:

	Ft.	In.
Limestone, *Cambridge*	5	4
Coal, *Wilgus*, reported	3	--

The coal has been mined in a number of places on this creek, but no banks are in operation at present, (1912.) Mr. Wilson reports the coal from 3 feet to 3 feet 6 inches, and the limestone about 6 feet in thickness.

Symmes Township.—The Cambridge limestone holds its thickness quite well as it extends northward across Symmes Township into Gallia County, but the Wilgus coal thins rather gradually until it is only about 1 foot in thickness or even less. In the western part of the township, the members are found near the summits of the high ridges at an elevation of about 950 feet, but along the Symmes Creek Valley in the eastern part they are found at an elevation of about 800 feet. The limestone is regularly used for road making, as it is available over most of the area; while the coal has been mined at only a few places and is not important at present. Near the mouth of Johns Creek in Symmes Township, on the property of A. T. Pyles, the Wilgus coal has been prospected by a drift mine at which the record given below was obtained:

	Ft.	In.
Limestone, *Cambridge*, seen	2	--
Coal, *Wilgus*	3	--

In Symmes Township, west of Symmes Creek and north of Johns Creek, both coal and limestone are quite persistent. On Stewart Knob there is a small area in which the bed has been worked for local use. The section is as follows:

	Ft.	In.
Limestone, *Cambridge*	4	--
Coal, *Wilgus*	1	8
Clay	1	--

North of Sherritts on the ridge between Johns and Buffalo creeks, the limestone and coal outcrop on the high points. At the mouth of an old mine, on the property of H. W. Stewart, the section measured is as given below:

	Ft.	In.
Limestone, *Cambridge*	4	--
Coal, *Wilgus*	3	--

Near the school house in a quarry the section taken is as follows:

		Ft.	In.
Limestone	*Cambridge*	1	10
Limestone, nodular		1	3
Limestone, solid		3	6
Coal, reported, *Wilgus*		3	--

Elizabeth, Decatur, and Washington Townships.—The Cambridge limestone, with the underlying Wilgus coal, is present on the high knobs on the main ridges in the northwestern part of Elizabeth Township. The Wilgus coal has weathered, so that it is but little more than dust. The limestone varies from 1 to 2 feet in thickness. Small isolated areas of these members are present along the main ridges in eastern Decatur Township. On Phillips Knob the following section was obtained:

	Ft.	In.
Limestone, *Cambridge*	4	--
Coal, *Wilgus*	2	--
Clay	2	--

The most northern exposure in Lawrence County is just west of Hoadley in Washington Township, where a section in a small mine is as given below:

	Ft.	In.
Limestone seen, *Cambridge*	2	--
Shale	2	--
Coal, *Wilgus*	1	10

The area above drainage in which the Wilgus coal carries a thickness of 2½ to 3½ feet, begins near the head of Long Creek, extends northward past Arabia, then across the ridge between Aaron and Johns creeks, and then across the ridge between Johns and Buffalo creeks north of Sherritts. Its maximum development is found in the region around Arabia and Wilgus. On Long and Buck creeks where it passes below drainage, it has good thickness, which it may hold for some distance. The deposit is persistent, but thins gradually westward from the main axis, and also east of this in the Symmes Creek Valley north of Waterloo.

Economic Value of Wilgus Coal

The Wilgus coal has a local value only. It furnishes the principal part of the fuel used at Wilgus, Arabia, and vicinity. The farmers on the ridges between Aaron and Buffalo creeks draw their main supply from this bed. In the future, after the thicker coals have been worked out, the Wilgus coal may be of considerable importance, as the area in which it is found is quite large, and as the conditions for mining are favorable, although the deposit is thin.

There are no regular partings in the bed, and it contains but little shale impurities in the main field in Symmes, Aid, and Mason townships. The Cambridge limestone is the roof material throughout the entire field, with the exception of small areas on Long Creek and in the southern part of the county, where shales intervene between the coal and limestone. With this exception there is no "draw slate" with which to contend. Along the outcrop, or under shallow cover, the limestone is usually weathered into shelly blocks, separated by mud partings, which form a dangerous roof. Under heavy cover the limestone is very solid and is but little jointed; hence it forms a roof of excellent quality. The floor material is generally a dense, siliceous, calcareous clay, and is solid enough to carry well the weight of the overburden on the mine props, ribs, and pillars without giving, in properly worked mines. The coal is very regular. There are but few small rolls in the floor, so that the mines are easily drained when driven against the dip. The coal is bright and solid and has the appearance of a short fiber cannel coal.

The minerals associated with the Wilgus coal are of small importance. The clay below, where examined, in most cases contains a considerable quantity of impurities in the form of ferrous and calcium carbonate nodules; consequently it is suitable only for low grade ceramic work. The Cambridge limestone above is generally siliceous and thin, but it has good use for road ballast or concrete work. The materials above the limestone are usually soft shales, which form dangerous mine roofs; hence, for safety in mining, part of the stone should be left for this purpose. This can be done, however, only in a part of the field, as the limestone is too thin. The Wilgus coal is an oily, free-burning, long-flamed coal. The ash is low, but clinkers considerably. Earnest Griffith, of the Arabia Milling Company, considers the Wilgus coal for steaming purposes superior to the Upper Freeport, and about equal to the Greasy Ridge or Pomeroy coal. An analysis of the Wilgus coal from a mine near Hoadley, made by Mr. Downs Schaaf, is as follows:

Moisture	3.90
Volatile matter	44.40
Fixed carbon	47.75
Ash	3.95
	100.00
Sulphur	3.17
Manganous oxide in ash	1.25
Specific gravity	1.29

It is also a coking coal, as shown by a test, but the yield is low, and the sulphur largely in the form of organic sulphides is entirely too high. It is rich in gas and tarry compounds. As already stated, the Wilgus coal at present is of value chiefly for a local fuel supply, or for a reserve when the thicker deposits have become exhausted.

Economic Value of the Cambridge Limestone

The Cambridge limestone is found over a wide area in Lawrence County, extending in a belt about 10 miles wide from the Ohio River to the northern boundary. Its western limit is practically the ridges that form the divide between the Symmes Creek and Pine and Storms creeks basins from the northern boundary of the county to Kitts Hill, then south from this point to Coalgrove. Its eastern boundary is close to Symmes Creek, from near its mouth to as far north as Willowwood, then northward to the heads of Long and Buck creeks and to the Lawrence-Gallia line, which then forms the boundary. The average thickness of this limestone is between 3 and 4 feet, with a maximum of 6 or 7 feet. It is best developed in the region extending from Marion Township, and from the head of Long Creek, in Aid and Mason townships, northward to Arabia, thence across the ridge between Aaron and Johns creeks to the ridge between Johns and Buffalo creeks, in Symmes Township, north of Sherritts. In this area the limestone usually is from 4 to 6 feet in thickness. The Cambridge limestone in Lawrence County is generally quite siliceous, which restricts it to a few uses; the most important of these are for road ballast and concrete work, for which it is largely used in the Symmes Creek Valley, where the higher grade Ferriferous limestone is less available.

AMES LIMESTONE

The Ames limestone, which lies about 80 feet above the Cambridge, is seldom present in Lawrence County. This member is very fossiliferous, and is a good guide for stratigraphic work. A thin bed of Ames limestone was noted on the McGuirr Hill south of Manker, in Lawrence Township, and another deposit was seen on the property of Ollie Moore, on Buffalo Creek, in Fayette.

FRUIT CULTURE

Southeastern Ohio should become one of the important fruit regions of the United States, as the land is especially adapted for the cultivation of apples. The fruit belt is that in which the country rock belongs to the Conemaugh and to the Monongahela formations, which are made up largely of highly calcareous and ferruginous shales having a deep red color, with occasional thin and nodular beds of limestone. In Lawrence County this belt includes the area from the eastern boundary of the county to about the central part, or, in other words, it includes that part of the county made up of the rocks above the Upper Freeport or Waterloo coal. Here the rocks of this interval are largely shales which are especially rich in calcium and magnesium carbonates, iron oxides and phosphates, some thick sandstone beds, and a few thin limestones. The residual soil thus contains most of the mineral foods demanded by the trees to produce a vigorous hardy growth. Clover does well; hence the soil may easily be enriched in the necessary nitrogen compounds at a small expense. The trees on this land are hardy, quite free from disease, and bear abundantly. The apples are of good size, very highly colored, excellently flavored, solid, and firm. They are not as large in size as the western apple, but are as highly colored and far better flavored. The keeping quality is equal to that of any of the western apples.

There are thousands of acres of these red shale lands in eastern Lawrence County, well located, and available for fruit culture. The land on the ridges is generally preferred to that in the valleys, as the frosts are less destructive. On many of these ridges there are large tracts on which fruit may be tended and harvested with ease. One of the most serious objections to fruit raising in this locality at present is a lack of proper marketing facilities, as the country roads are poor and the railroad service is inadequate. Compared to that of western fruit lands, the price of these lands is very low; consequently, for the same capital, the acreage will far exceed that in the west. Further, a more intelligent and cheaper labor may be secured in this locality than is obtained in the west, and the fruit is closer to market. Fruit raising in southern Ohio is not an experiment, as some very fine orchards are located in Lawrence and Gallia counties. This industry should be encouraged and extended.

A.—Apple orchards on Greasy Ridge, Lawrence County.

B.—Near view of a peach orchard on Greasy Ridge.

CHAPTER III

EASTERN HALF OF PIKE COUNTY

The minerals of Pike County have been but little developed, although deposits of shale, sandstone, conglomerate, and coal are found, which in the future may lead to the establishment of important industries. The region is too far west to contain notable amounts of ores, which, through the charcoal iron industry, brought about early activity in the winning of the minerals of the counties eastward. The most striking geological feature is the massive stratum of Sharon conglomerate marked by the bold cliffs on the points, or by the long line of steep escarpments along the main ridges, or by the abrupt walls of the gorges along the headwaters of the small streams, where the rocks with the varied profusion of plant life yield a wildness both beautiful and impressive.

Location and Area

Pike County, dissected by the Scioto River, is bounded on the north by Ross, on the east by Jackson, on the south by Scioto and Adams, and on the west by Highland. According to the latest government estimate the area is 470 square miles.

Topography

RELIEF

In this report only that part of Pike County east of the Scioto River will be considered. The region is a part of the old Appalachian Plateau, the outline of which may be observed by standing on one of the high hills, and by following with the eye the elevations of the high ridges, and of the hills which thus approximately mark the original plane. This plateau was first traversed by a system of rivers flowing northward, which, cutting deep into the rock strata, produced the general outlines of the present relief. During the glacial epoch a reversal of the drainage took place, which gave rise to the present system of drainage and caused many of the old waterways to be modified or even abandoned. The present streams have been active in cutting new beds or deepening the old ones, and in extending their headwaters farther into the highlands. The resultant of the forces acting is shown by the highly dissected character of the region, which, excepting the valleys of the Scioto, and the preglacial California rivers, and remnants of the valley of the old Portsmouth River, is made up of steep hills with narrow valleys. In Pike County the width of the California Valley is from 1½ to 2 miles, that of the Scioto from 2 to 3½ miles, and the fragments of the Portsmouth Valley from 1 to 2 miles. The summits of the main ridges just east of the Scioto often rise to an altitude of more than 1,100 feet, while the flood plains of the small streams below are about 600 feet above tide. Along the eastern boundary of the county, the elevation of the crests of the main ridges is about 1,000 feet, and that of the valley plains nearly 700 feet. Thus the slope of the Appalachian Plateau is eastward; hence, measuring from the level of the small streams, the ridges near the Scioto rise approximately 200 feet higher than those along the eastern border of the county.

The relief of the region is also influenced by the character of the rock strata. The formations above drainage in that part of Pike County east of the Scioto River are Cuyahoga, Logan, and lower Pottsville. The Cuyahoga formation is made up of sandy shales with thin and medium bedded sandstone interstratified, but the former constitute the main mass of the deposits. The next formation in ascending order, the Logan, which in the main is also composed of sandy shales, contains in some localities thick strata of argillaceous sandstones. Above this comes the Pottsville formation, the basal member of which is the Sharon conglomerate, represented in a part of the territory by massive deposits of pebbles and sands. The difference in the topography of the territory, where the hills are composed of Cuyahoga and Logan strata, from that where the hills also contain thick deposits of Sharon conglomerate, is striking. In the former region the features forcibly pronounced are the narrow, sharp ridges, the steep but gradual slope of the hills, and the V-shaped valleys of the small streams, while in the latter the features characteristic are the broad ridges on which are found many good upland farms, the abrupt declivity of the hills with many high precipices, and the constricted U-shaped valleys of the small streams. The nature of the outcropping rocks thus influences, to a marked degree the character of the surface, for the relief in Seal, Scioto, and western Jackson, Beaver, and Union townships, where the strata exposed are Cuyahoga and Logan shales and sandstones, is noticeably different from that in Marion, and eastern Jackson and Beaver townships, where massive deposits of Sharon conglomerate are exposed.

A study of the relief shows that the Sharon conglomerate, although its texture is open and the particles poorly cemented, is more resistant to weathering agencies than the shales and sandstones of the Cuyahoga and Logan formations, but when the abrasive action of streams is considered the effects are reversed. The differential effects of weathering are shown in traveling the ridges, for here if the rocks exposed are Logan shales and sandstones, they are very narrow, often scarcely wide enough for a wagon road, but if the Sharon conglomerate comes in, they widen to a marked degree thus producing easily tillable land. Many good upland farms are found on the ridges just above the outcrop of the Sharon conglomerate, while but few occur where the prevailing rocks are Cuyahoga and Logan.

The difference in the cutting power of streams acting on the thick stratum of Sharon conglomerate or on the shales and sandstones below, is shown by observation of the valley walls and the stream gradients. Streams acting on the conglomerate seem to drop through the deposit, the declivity is abrupt and the valley walls very steep or precipitous, but those acting on the shales and sandstones, have regularly changing gradients and more constantly sloping walls.

The resultant of the forces of weathering and stream action on the different classes of rocks is especially well illustrated by the relief in Jackson Township. Here in the western part, east of the Scioto River, the rocks are shales and sandstones of the Cuyahoga and Logan formations, and the features are narrow ridges with steep but constant slopes, and regularly changing stream gradients. In the eastern part, the Sharon conglomerate comes in with force, often measuring 150 feet in thickness, and the features noticeable are wide ridges with the outcropping conglomerate marked by lines of rugged cliffs and steep escarpments and the abrupt descent of the stream through this member.

Present Drainage

The Ohio River receives through the Scioto and the Little Scioto rivers the waters from the entire area. The Little Scioto drains eastern Beaver, eastern and southern Marion and southern Union townships. The Scioto, with the aid of a number of small tributaries, drains the remainder of the area. A few small runs flowing directly to the Scioto drain southern Scioto Township. Beaver Creek drains northern Scioto, northern Union, northwestern Marion, western Beaver and all of Seal, excepting a narrow strip along the Scioto and a small territory in the northern part drained by Marcus Run and Straight Creek. The Scioto, with its small tributaries, the most important of which are Straight Creek, Cars, Mutton, and Hickson runs, drains directly all of Jackson Township with the exception of a few sections in the eastern part, which are drained by western tributaries of Pigeon Creek, whose waters finally reach the Scioto through Little Salt and Salt creeks.

Beaver Creek, which follows throughout most of its course the old Teays River Valley, is the largest stream entirely within the area. Its course is tortuous and the stream under normal conditions sluggish. The numerous small streams rising in the hilly lands are eroding streams, active in both deepening and widening their valleys. During rainy seasons their currents are swift, and they transport heavy loads of broken stones, gravel, and sediments. The work of the Scioto is mainly that of removing glacial debris from its valley.

The railroads crossing the county follow the main drainage lines. The county and township roads are usually located in the valleys, although in the eastern part some follow the principal ridges.

Preglacial Drainage

Pike County was dissected by the Teays River, the main stream of the old Kanawha drainage system, and by one of its important tributaries, the Portsmouth River, the general descriptions of which have been given in the discussion of the drainage features of Lawrence and Scioto counties. The Teays River, the course of which is well defined by the broad valley that it eroded through the hilly country, entered Pike County near Stockdale. From here, making a great bend, it flowed across the corner of Marion Township into Scioto Township, Jackson County, thence northward to Glade, and thence westward, entering Pike County in the northern part of Marion Township. From this point it flowed on westward to Waverly, thence turning abruptly, flowed northeastward to Richmondale, Ross County. Its course has also been traced from Richmondale northward past Londonderry and thence northwestward to Chillicothe, where the old bed is buried with glacial drift.

The old valley is especially well defined from the Scioto River near Waverly to the eastern boundary near Beaver, as its valley floor, bordered by hills rising from 200 to 300 feet above, is from 1 to 2 miles in width. Judging from the elevation and nature of the deposits northward from Waverly, the upland plain, lying between the flood plains of the Scioto and the hills to the west, is evidently a fragment of the old valley, the most of which was obliterated by the present stream. For a complete discussion of the subject, the reader is referred to the work of Tight, "Drainage modification in southeastern Ohio and adjacent parts of West Virginia and Kentucky,"[1] and also that of Leverett, "Glacial formations and drainage features of the Erie and Ohio basins."[2]

The largest tributary uniting with the Teays River, in Pike County, was the Portsmouth, which is defined by Tight as follows: "It is therefore evident that at Waverly this old Kanawha drainage received a large tributary from the south, which included the waters of Salt Creek and Kinniconick Creek of Lewis County, Ky., with the minor tributaries, and that the old direction of this drainage was along the reversed Ohio to Portsmouth, and from Portsmouth along the reversed Scioto to Waverly."[3]

Stratigraphic and Economic Geology

All the consolidated rocks appearing at the surface in Pike County, east of the Scioto River, belong to the Devonian, Mississippian, and Pennsylvanian systems, while the unconsolidated clays, sands, and gravels found on the floors of both the present and preglacial streams, belong to the Quaternary. The Devonian system in this area is represented only by the Ohio formation, which is not exposed in its full thickness at any point. This formation, which is made up largely of shales, has not yet been divided into members. The rocks of the Mississippian and Pennsylvanian systems are subdivided into formations and members. The six formations of the Mississippian series, Bedford, Berea, Sunbury, Cuyahoga, Logan, and Maxville, are present in eastern Pike County, but the Maxville is represented only by scattered fragments of cherty limestone. Of the four formations of the Pennsylvanian system, Pottsville, Allegheny, Conemaugh, and Monongahela, only the lower one, the Pottsville, is present. The Mississippian strata consist, in the main, of shales and sandstones, but they also contain conglomerates, fragments of limestone, and nodular ores. The Pennsylvanian rocks are conglomerates, sandstones, shales, clays, coals, limestones, and iron ores. The total thickness of Mississippian rocks is between 600 and 700 feet, while that of the Pennsylvanian is about 300 feet. At present the latter are of chief interest as they carry coal of workable thickness. In this report the Quaternary rocks are first described, then the Mississippian and Pennsylvanian rocks, which are treated in more detail, are considered in ascending order, beginning with the oldest.

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[1] W. G. Tight, Professional Paper 13, U. S. Geol. Survey.

[2] Frank Leverett, Monograph XLI, U. S. Geol. Survey.

[3] W. G. Tight, Professional Paper 13, U. S. Geol. Survey, pp. 72-73.

A General Table of the Rock Strata in Eastern Pike County

System.	Series.	Formation.	Member.
Quaternary	Recent Pleistocene		Recent alluvium and gravel deposits. Glacial and old stream deposits.
Pennsylvanian		Pottsville	Anthony coal. Sciotoville clay. Sharon iron ore. Sharon coal. Sharon conglomerate.
Mississippian		Logan	Vinton sandstones and shales. Allensville sandstones and shales. Byer sandstone.
		Cuyahoga	Portsmouth shales. Buena Vista sandstones. Henley shales.
		Sunbury	
		Berea	
		Bedford	
Devonian		Ohio	

PLEISTOCENE SERIES

Glacial and Old Stream Deposits

The heavy deposits of clays and sands found on the floor of the Teays Valley, which extends from the Scioto River eastward past Beaver to Glade, Jackson County, and thence southward to Stockdale, and also those deposits found on the floor of the fragment of the Portsmouth Valley, in Scioto and Seal townships, were laid down during Pleistocene time. The sands in the main are fine-grained and argillaceous. The clays vary in texture from a rather open or porous body to one very dense and impervious; in color, from a light gray to a dark brown; and in composition, from those containing notable amounts of silica, iron oxides, and lime, to those in which these components are quite low. When seen in cross section these clays have a jointed structure, which in most cases is well defined. The clays, which are found along the margins of the valley, and on elevated points and divides, and which were deposited during the slack-water period, are characterized by their high degree of stratification. The thickness of the deposits on these old valley floors varies from 30 to 60 or more feet.

Economic Value

The clays of the Pleistocene series have some value for the manufacture of ceramic products, although they are but little used in Pike County. They are well suited for the making of red brick and drain tile especially. The winning of the clay from the deposits is accomplished at a low cost, as it only involves stripping off the soil and digging by plow or mattock. Plastic muds are formed by simply working the clay with water in a pug mill, but this process is hastened by preliminary grinding of the lumps by a roll crusher. The muds thus formed flow through the dies of the brick or tile machine with but little defects, especially if the clays used are somewhat siliceous. If the clays used are highly plastic, such as those produced during the slack-water period, laminations, which cause loss of ware during drying and burning, are produced. The ware checks with rapid drying, but, with a reasonable amount of care in regulating the temperature and air currents, it dries safely, and has good toughness, withstanding easily the handling in setting. The ware burns to a good dense body at a low temperature, but the total shrinkage, both drying and burning, is relatively high, usually averaging from 1¼ to 1½ inches per foot. With tile some ware is lost on account of warpage. In color the ware ranges from a light red to a dark brownish red. The only plant in Pike County working these clays at present is the Beaver Tile and Brick Company, the following description of which was furnished by the general manager, John A. Stout:

> The plant, located one mile west of Beaver, was built by Theobald Bros. in 1911, but has since been rearranged and enlarged. The clays used are the silt deposits in the old

A—Barnes Sand & Gravel Company's plant near Wakefield, Pike County. Glacial drift gravel from the flood plains of the Scioto River is mined, sized, and washed for the general market.

B.—Typical Waverlyan topography in the eastern part of Pike County.

river valley; the stratum worked at present has an average thickness of about 10 feet. The power is furnished by an Atlas 60-H. P. boiler and engine. The clays are first crushed by a roll disintegrator, then worked into a soft mud by a common type pug mill. The mud is shaped into ware by a No. 281 auger machine, made by American Clay Machinery Co. This ware is handled on 60 triple-deck steel cars with transfer cars. The drying is done by exhaust steam from the engine or live steam from the boiler. The ware is burned in three 25-foot downdraft kilns and the fuel used is No. 1 or Jackson Shaft coal. The capacity of the plant is 15 M. brick or 10 M. 4-inch tile. The plant has a yard-level switch from the Detroit, Toledo & Ironton Railway, over which a large part of the ware is shipped. Standard tile from 3-inch to 12-inch, with shapes for connections, and common building brick are kept in stock. The firm also operates one Buckeye traction stream ditcher, size 11½ inches by 4½ feet, and controls by lease 40 acres of Jackson Shaft coal land from which at present the main supply of fuel is drawn.

Along the Scioto Valley, gravels and sands deposited in Pleistocene time are worked for local use. Formerly this gravel was used quite extensively for railroad ballast and road facing, but at present the gravel has been supplanted largely by limestone. These gravels and sands are excellent materials for concrete and mortar work, as they are usually quite free from silt and coal particles. At present at no point in the county are these materials regularly mined and marketed.

Recent Deposits

Along the flood plains of the small streams the deposits consist of interbedded gravels and alluvium, which, due to the variable nature of the deposition, have no practical value. Along the Scioto the deposits in the main consist of glacial gravel and sand, with a surface coating of alluvium. Where this material has been worked over by the streams, and thus differentially separated, beds of clean sand or gravel are found, which are used locally to a small extent. The sand is used for mortar work, and the gravel for concrete and road facing.

DEVONIAN SYSTEM

OHIO FORMATION

The Ohio formation, commonly known as the Ohio shales, is the only division of Devonian rocks appearing at the surface in the eastern half of Pike County. Its outcrop, found at the base of the hills, extends along the Scioto River from near Wakefield north to near the mouth of Marcus Run, in Seal Township. The formation is nowhere in this vicinity exposed in its entire thickness, only a thin section of the upper part being above drainage level. Owing to the deep covering along the valley these rocks are seldom exposed for observation, except in the beds of the small streams as they enter the flood plains of the Scioto River. The rocks of the Ohio formation in this locality are black shales, containing about 10 per cent carbonaceous matter, to which the coloration is primarily due. The stratification planes are closely spaced, thus allowing the shale to be split into thin sheets. These shales are rather hard and tough; hence they are more weather resistant than the average shales. The Ohio shales are not well fitted for ceramic uses, as their working qualities are poor, and as the concretionary and carbonaceous matter contained cause serious trouble during the burning of the product. When the supply of oil and gas, which nature has stored in the rocks below, is exhausted, the shales may be utilized for the production of these valuable fuels now so largely used. When these shales are subjected to destructive distillation they yield both oil and gas, as the carbonaceous matter is broken down into such compounds. At present the shales of the Ohio formation have but little practical value, but in the future they may be useful in contributing to the needs of mankind.

MISSISSIPPIAN SYSTEM

The rocks laid down during the early part of Mississippian time are shales with thin to medium bedded layers of argillaceous sandstones. They indicate deposition in quiet waters, which at times at least were shoaly, as the sandstones are usually highly ripple marked. The rocks above these are siliceous shales and shaly sandstones, while those laid down during the latter part of the epoch are shales, sandstones, and a limestone. The sandstones, containing differentiated layers of coarse and fine materials, and showing some cross bedding and ripple marks, suggest deposition by currents both in open waters and along old sea beaches. The limestone, deposited in quiet waters, was later nearly completely removed for only scattered fragments of the deposit now remain. Mississippian time was one of general subsidence, although slight elevations occurred as shown by a few small disconformities.

The rocks exposed at the base of the hills east of the Scioto belong to the Mississippian system. The rocks exposed on the crests of the highest points in Scioto and in Seal townships, with the exception of two knobs in the eastern part of Seal, are Mississippian. In western Union, Beaver, and Jackson townships the highest hills and ridges are capped by Pennsylvanian strata. The dip of the strata south of east, measured by using the Allensville conglomerate as the basis, is 39 feet to the mile. The Mississippian rocks extend eastward entirely across the county and go below drainage in the western part of Jackson County. Along the eastern boundary of the county the elevation of the upper surface of the Mississippian is from 800 to 900 feet, generally about 850 feet or from 100 to 200 feet above drainage. The Mississippian system, as already stated, is divided into six formations, which will now be considered in ascending order. As these rocks are being investigated by another member of the Survey, J. E. Hyde, they will be treated only in a general way.

BEDFORD FORMATION

The Bedford formation, in eastern Pike County, is found along the Scioto Valley from the southern boundary line to the northern part of Seal Township. It is made up of shales in which some thin to medium bedded layers of sandstones are interstratified. Lithologically these shales differ greatly from those of the underlying Ohio formation, but they are somewhat similar to those of the Cuyahoga division of rocks, which is found higher in the geological column. The sandstones resemble those of the overlying Berea and Cuyahoga formations, but they are thinner bedded, finer grained, more argillaceous and more widely spaced.

In the main these shales are rather soft, and on weathering, they crumble to fine powders. In some localities layers near the upper part of the formation are clay-like in character. Good plasticity is always developed in these shales by weathering or by working with water. They are somewhat less siliceous than the shales of the Portsmouth member of the Cuyahoga formation. The color of the main body of the deposit is light gray or bluish gray, while that of the clay-like layers is usually mottled with iron oxide pigments.

BEREA FORMATION

In eastern Pike County, the Berea formation is above drainage along the Scioto Valley, from the southern line to near the mouth of Cars Run in Jackson Township. It is made up of sandstone beds with which thin layers of shales are interstratified. The sandstone layers vary in thickness from 1 inch or even less to as much as 7 feet, but most of them measure between 6 inches and 2 feet. The beds are regularly jointed by planes which cross at approximately right angles. A few layers have a concretionary structure, often very pronounced. These sandstones are highly ripple marked, and the layers of siliceous shales also show the same features. The stone is composed of quartz sand with a small amount of argillaceous matter and iron compounds for the bonding components. Most of the beds are quite weather resistant, but a few layers crumble when exposed to severe conditions. Only a few observations were made regarding the thickness of the formation, which varies considerably from place to place, but these views indicate that the thickness is from 20 to 40 feet. In eastern Pike County, the Berea sandstones have been worked for shipment in only one locality, which is at Piketon. A description of the quarry follows:[1]

A quarry in the Berea sandstone was opened many years ago on a hill at Piketon. It was operated on a small scale, but was abandoned perhaps 25 years ago. Following is a section in this quarry:

	Ft.	In.
Sunbury shale	20	--
Berea sandstone.		
Sandstone, buff to brown. Splits into irregular layers	6	6
Sandstone, shelly on top	1	3
Sandstone, gray to buff. Broken in places	2	--
Sandstone, shelly on top, and ripple marked	1	1
Sandstone, shelly on top	--	9

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[1] Geol. Surv. of Ohio, Fourth Series, Bull. 18, pp. 106-7.

Berea sandstone.	Ft.	In.
Sandstone, shelly on top. Buff color, but streaked on top with brown	2	--
Sandstone, shaly	--	4
Sandstone	1	7
Shales	--	3
Sandstone	--	11
Shales	--	2
Sandstone	--	9
Shales	--	2
Sandstone	1	6

The layers in this quarry, except the top 6 feet, are quite regular, and nearly always separated by from 1 to 4 inches of shales. The rock is not much broken nor is the concretionary structure prominent. The stone had a large market on the Norfolk & Western Railway, which used it for bridges.

As a general thing the layers are somewhat thinner elsewhere than they are at Piketon, although at all places where the formation was examined, some of the beds have good thickness. These sandstones are valuable building material, but care should be exercised in the selection of the resistant layers, and in the proper grading of the stone. At present, in eastern Pike County, the Berea sandstone is used only for local needs.

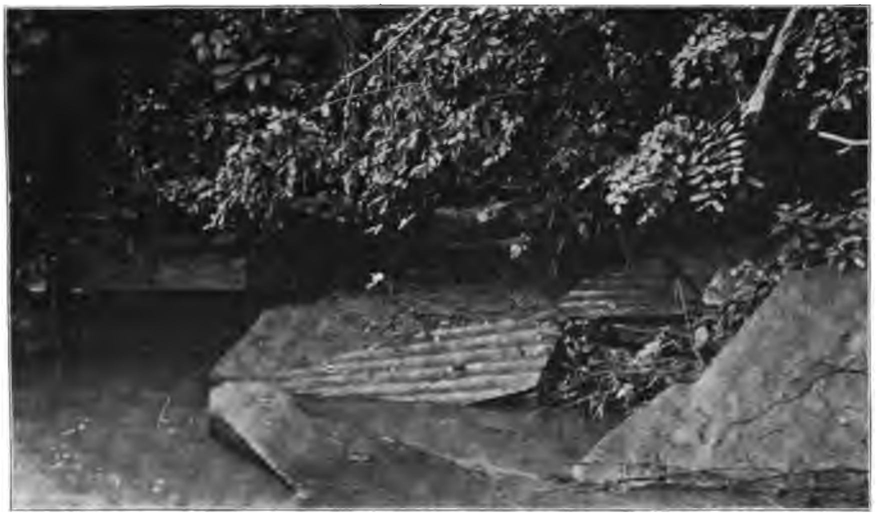
SUNBURY FORMATION

The area of the Sunbury formation in eastern Pike County is confined to a narrow belt extending along the Scioto River, and the lower courses of its small tributaries, from the southern boundary of the county to the central part of Jackson Township. The formation is made up of shales, which in many respects resemble the shales of the Ohio formation. Owing to the presence of carbonaceous matter they are dark colored, varying from coffee brown to nearly black. These shales are hard, bony, and fissile. They are also quite weather resistant, but when reduced by the elements they flake off in thin sheets instead of crumbling to powders. These shales are often highly charged with small nodules of pyrite, yet they seldom contain concretions of other materials. The thickness of the formation, where measured, is from 15 to 30 feet, but these figures may not represent the extremes. The average thickness observed is about 20 feet.

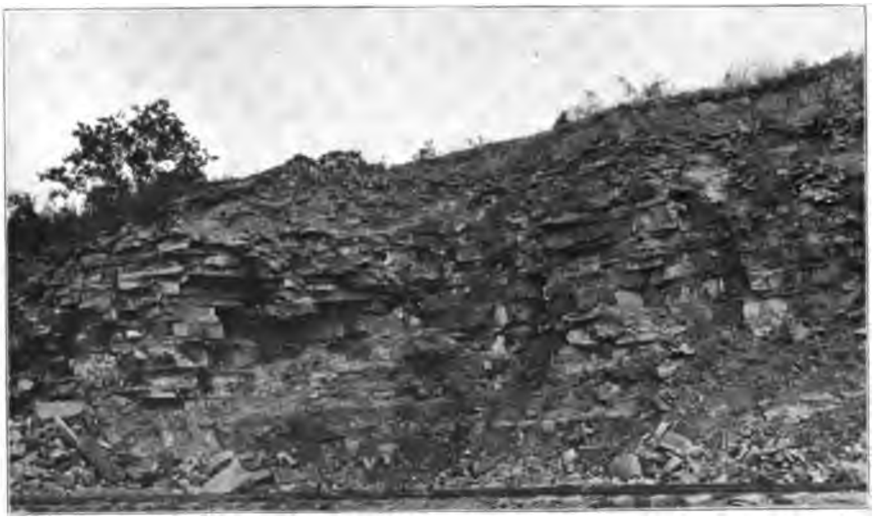
At present the Sunbury shales have no economic value, but, owing to the content of carbonaceous matter, in the future they may be utilized as a source of oil and gas. They have no ceramic value.

CUYAHOGA FORMATION

The Cuyahoga formation includes the shales and sandstones from the Sunbury black shales below to the Logan shales and sandstones above. The contact of the Cuyahoga and Logan formations is not sharply defined in most of the area. In some localities the line of di-



A.—Ripple-marks on the upper surface of the beds of the Berea sandstone along the stream east of Wakefield, Pike County.



B.—An exposure of Berea sandstone in the cut of the Norfolk & Western Railway near Clifford, Pike County.

vision is marked by a slight disconformity that exists between the shales of the Cuyahoga and a heavy sandstone above, which has been named by Hyde the Byer member of the Logan. In other localities, where the Byer sandstone is poorly developed, the shales and sandstones of the Cuyahoga blend with those of the Logan with no apparent definite break; the interval from fossil horizons and texture changes is then the main reliance in separating the two formations. The thickness of the Cuyahoga formation varies usually between 300 and 340 feet. Primarily the formation is made up of shales, but in the lower half, especially, thin to massive layers of sandstone are found which may lie close together, or may be separated by intervals of many feet. They are correlative with the freestones worked at McDermott, Buena Vista, and Careys Run, in Scioto County.

Along the road on Straight Creek, just below the mouth of Meadow Run, in Section 8, Seal Township, one of the heavy brown stone layers is exposed. The layer varies from 2 to 4 feet in thickness, and the stone has an attractive brownish color.

In Section 2, Jackson Township, on land of Peter Bauer, several layers of the brown stone are exposed, one of which has a thickness ranging from 5 to 6 feet, where measured. The layer is broken into large blocks by joint planes, but is quite free from partings along the bedding planes. The stone is medium fine-grained and has good color. It is quite weather resistant, as the stratum stands out in bold relief along the hillside at an elevation of about 70 feet above the flood plain of the Scioto River. The thinner layers exposed below were not measured.

An exposure of the brown stone layers was also seen along the roadside near the Brown School, in Section 1, Jackson Township. A partial section taken at this point follows:

	Ft.	In.
Sandstone, brown	1	3
Shale	1	6
Sandstone, brown	--	9

South of this, along the road in Straight Creek, near the central part of Section 10, one of the layers is exposed, and measured as given below:

	Ft.	In.
Sandstone, shelly	--	8
Sandstone, solid	1	8
Shale, blue, soft	2	--

The upper 8 inches of shelly stone, which has been loosened by weathering, is a part of the layer. Under heavy cover the entire bed is solid. The heavy layer seen on land of Peter Bauer is also exposed in a number of places near the base of the hills facing the Scioto River. It is persistent from his home north to the mouth of Cars Run. In the southwestern corner of Section 4, Jackson Township, on land of M. P.

Foster, the layer ranging in thickness from 3 to 4 feet is found about 60 feet above the Scioto flood plain. The average thickness of the blocks measured was 3 feet 6 inches, and the quality of the stone very good. North of this in an old quarry, from which a small amount of stone had been taken for some local use, the layer measured 3 feet 6 inches, and the interval from it to the Sharon conglomerate, which caps the point, measured 260 feet. (Aneroid). Near the mouth of Cars Run the thickness exposed at one point was only 2 feet 6 inches. On Cars Run, near the Baptist Church, in Section 5, Jackson Township, brown sandstone layers are exposed at a number of points. The thickest layer seen measured from 1 foot 6 inches to 4 feet, averaging about 2 feet 6 inches to 3 feet. In the same section, near the mouth of Jackson Fork, a layer exposed measured from 1 foot 6 inches to 3 feet. Near where the road crosses Cars Run, in the northeastern part of Section 27, the following measurements were made:

	Ft.	In.
Sandstone, brown	2	4
Shale	6	--
Sandstone, brown	1	1
Shale, with thin sandstone layers	10	--
Covered	13	--
Sandstone, brown	1	8
Shale	2	--

Near the mouth of Hay Hollow, in Section 28, a layer exposed along the road measured 2 feet 9 inches in thickness. East of this, on land of John Richenbaugh, the section given below was measured along an old road:

	Ft.	In.
Sandstone, brown	1	8
Shale and covered	8	4
Sandstone, blue	--	4
Shale	2	--
Sandstone, brown	--	11
Shale	--	8
Sandstone, brown	--	9
Shale	5	6
Sandstone, gray	--	6
Shale and covered	18	--
Sandstone, gray	--	5
Shale	7	--
Sandstone, brown	2	6
Shale	14	--
Sandstone, gray	--	10
Shale	6	--

One of the brown sandstone layers, measuring from 3 feet to 3 feet 6 inches, is exposed on the point north of the home of George Anderson, in Section 25, Jackson Township. The stratum, here about 30 feet above the flood plain of the Scioto, is correlative with the heavy layer exposed along the Scioto Valley south of Cars Run. North of this on land of Joseph Acord, layers measuring from 1 to 2 feet in thickness were seen.

Near the mouth of Hickson Run, in Section 17, Jackson Township, on land of Pearl E. Cash, the following measurements were made of the strata exposed along the bank of the stream near the river road.

	Ft.	In.
Sandstone, brown	1	2
Shale	1	--
Sandstone, brown	2	6
Covered	9	2
Sandstone, brown	1	3
Shale	--	9
Sandstone, brown	--	3
Shale	1	6
Sandstone, brown	--	10
Shale	2	1
Sandstone, brown	--	7
Shale	--	2
Sandstone, brown	--	11
Shale	1	--

This series of brown sandstones continues northward to Richmondale in Ross County. Some of the upper layers were also noticed along Little Salt Creek.

Economic Value

The weather resistant character of both the gray and brown sandstone layers at once stamp them as fit material for building purposes. Not all the layers though are sufficiently durable for exposed work, for some are shaly and break up on weathering. Both care and judgment should be exercised in selecting and grading the materials. The medium and massive bedded layers are usually the most durable, although this quality is not a function of thickness, for some layers measuring only a few inches are far more resistant than others measuring from 1 to 3 feet. In some layers the blocks show a faint concretionary structure, and on exposure break along concentric lines into spheroidal masses.

The coloring of both the gray and brown varieties is due mainly to the amount and to the state of the iron component present. This in the gray stone is present in the ferrous or reduced state mainly, while in the brown stone the iron has been oxidized to the ferric state. From surface indications the brown stones change gradually into the gray as the cover thickens. The layers in the brown stone series contain a larger amount of iron minerals than the layers in the gray stone series below, for the latter on weathering give only pale browns and yellows, which are not attractive. This is also shown by the association of the gray and brown stone layers found in some sections where the conditions for weathering were equally favorable to both. The difference between the composition of the material in the gray stone series and that in the brown stone series is shown by the following analyses made by Professor Wormley.[1]

	Gray or blue stone	Brown stone
Silicic acid	91.00	73.90
Protoxide of iron	1.17	-----
Sesquioxide of iron	0.30	13.44
Alumina	5.20	8.56
Lime	trace	trace
Magnesia	0.28	0.46
Water, combined	1.80	3.30
Total	99.75	99.66

With a few exceptions both the gray and brown varieties are fine-grained, rather dense sandstones with clay and ferruginous minerals for the bonding material. The grains in the brown sandstone are usually somewhat coarser than in the gray. The bedding planes in both are usually too faint to give pronounced cleavage along these lines, the blocks breaking about as well in one direction as the other. On exposure, due to loss of water and oxidation changes, the rocks harden, but the fresh material is easily worked. The colors also in the weathered material are more permanent, so for exposed ornamental work this grade of stone should be used.

Both the brown and gray sandstones are well suited for building stone as they are strong and durable. There is a large amount of this material available in Pike County east of the Scioto River, as the outcrop of the strata extends from Scioto County northward to Ross. Along the outcrop and in restricted localities where the cover is shallow, the thicker layers should yield a large amount of high-grade material, suitable for plain and ornamental architectural work or heavy masonry. The deposits are not regularly quarried and marketed, at present, at any place east of the Scioto River.

LOGAN FORMATION

The Logan formation is sub-divided by J. E. Hyde into three members, Byer, Allensville, and Vinton. They are made up of shales, sandstones, and fine-grained conglomerates. The Logan formation usually ranges in thickness from 100 to 150 feet. A section taken at the head of Buck Hollow, in Section 16, Jackson Township, shows the general character of the members:

	Ft.	In.
Pottsville formation.		
Sandstone	5	--
Shaly sandstones and shales	40	--

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[1] Geol. Surv. Ohio, Vol. V, pp. 599-600.

Logan formation.		Ft.	In.
Sandy shales, with sandstone layers, *Vinton*		30	--
Shales, part sandy	*Allensville*	20	--
Sandstone		2	6
Conglomerate		--	11
Sandstone		--	11
Conglomerate		5	4
Shales, with sandstone layers, *Byer*		30	--

Economic Value

The sandstones in the Logan formation are seldom sufficiently strong or durable for building material, and the color is unattractive. The shales are usually siliceous, and not of the desired quality for ceramic purposes. They will make brick for common uses, but the ware is too glassy for paving material. The conglomerates in the Allensville are made up of quartz pebbles, averaging about the size of wheat grains. Where the beds are of any considerable thickness, and easily available, possible uses for the material are for sand-blasting, abrasives, gravel coating of roofing materials, or poultry grit. On the whole, at present, the rocks of the Logan formation have but little economic value.

MAXVILLE LIMESTONE

In Pike County the Maxville limestone is represented only by scattered fragments of cherty material, found along the contact zone of the Pennsylvanian and Mississippian rocks, between which a pronounced disconformity exists. If the rocks of the Maxville limestone were laid down here, they were so completely removed by erosion before the deposition of the Pottsville material that only cherty fragments remain. The erosion agencies not only removed the Maxville, if deposited, but also in places cut deep into the Logan. A drop of from 50 to 75 feet in one-fourth mile in the elevation of the upper surface of the Logan is not uncommon, and here the Sharon conglomerate thickens proportionally. Evidently the formations were elevated above the water at the close of the Mississippian period, and were thus subjected to erosion for some considerable duration of time. Since the removal of the limestone is so complete, it hardly seems probable that the deposits had a thickness comparable with that found in eastern Scioto and southern Lawrence counties. The condition here rather suggests thin local deposits, or the cherty material found may have been brought in by currents from deposits to the south in Scioto County, or to the east in Vinton, where remnants of limestone strata yet remain.

PENNSYLVANIAN SYSTEM

POTTSVILLE FORMATION

The next formation in ascending order found in eastern Pike County is the Pottsville, which forms the base of the coal-bearing rocks. There is a pronounced general difference in the nature and kinds of materials making up the Pottsville strata from those making up the Cuyahoga, Logan, and Maxville below. The Maxville limestone, when normally developed, is thick and quite pure, while the limestones found in the Pottsville are thin and generally siliceous. The sandstones in the Cuyahoga and Logan formations are compact, fine-grained, and, with few exceptions, argillaceous, while in the Pottsville the sandstones are open, friable, coarse-grained, and often highly micaceous. The shales of the former are siliceous, rather coarse-grained, and moderately plastic, while the shales of the latter are finer-grained, more plastic, and aluminous, and many contain notable amounts of carbonaceous matter. Coals and high-grade flint and plastic clays, common in the Pottsville, are not found in the formations below. The massive conglomerate at the base of the Pottsville is scarcely comparable with the thin fine-grained conglomerate of the Logan. In all respects there is a decided change in the character of the Pottsville rocks from those below. The Pottsville opens another chapter in the history of sedimentation.

The thickness of Pottsville rocks in Pike County is about 300 feet, of which about half is conglomerate,while the remainder is clays, shales, sandstones, coals, and iron ores. Only the lower part of the Pottsville is present, as the highest strata exposed are just below the horizon of the Quakertown or Wellston coal. The members present are Sharon conglomerate, Sharon coal, Sharon ore, and Sciotoville clay, which are taken up in ascending order.

SHARON CONGLOMERATE

Stratigraphy

The Sharon conglomerate, the basal member of the Pottsville formation, normally is a massive conglomerate with coarse quartz pebbles, but in some localities these are wanting and there the member is a coarse-grained sandstone. In fact, the composition of the stratum grades from a sandstone to a loose conglomerate with but little fine material. These changes in the stratum may occur either in a short distance horizontally, or in a few feet vertically.

As a general rule, the conglomerate is highly cross-bedded; the horizontal planes vary from an inch or two, to several feet apart, while the inclined planes are usually closely spaced. The stratum seldom shows distinct breaks in deposition, except along the border of the field and in a few localities where the Sharon coal, which will be treated later, is present. The pebbles and sand grains are well rounded and polished, although at least 90 per cent of the material is crystallized quartz. In disappearing, it is characteristic for the stratum to end rather abruptly; it seldom thins out gradually as do the members above or below. De-

A.—Sharon conglomerate near Stockdale in eastern Pike County. The largest pebbles are about 1 inch in diameter.

B.—Brecciated bed composed of flint from the Maxville limestone, quartz pebbles from the Sharon conglomerate, and iron oxides for the bonding component found on the contact of the Mississippian and Pennsylvanian systems. This bed is quite conspicuous in the southeastern part of Pike County.

posits 50 or more feet thick in one hill may not be represented in the next. Both the upper and lower surfaces of the conglomerate are also very irregular, the resultant of which gives great variation in the thickness from place to place. In Pike County the thickness of the Sharon conglomerate varies from a few feet to at least 150 feet, the latter noted in eastern Jackson Township. The conglomerate seems to fill the depressions in the surface of the Logan, which may represent basins or old channel ways, but appear more like the former.

The origin of the Sharon conglomerate is a subject of interest. The material is largely crystallized quartz, and thus of igneous origin derived from the granitic rocks. Evidently the source was Archean rocks of the Laurentian Highlands or of the old Appalachians, but the northward trend of the conglomerate, the comparative size of the two fields, and the barriers along the granitic axis of the Appalachians, strongly favor their derivation from the great fields of crystalline rocks to the north. When the area of the conglomerate, the thickness of the stratum, often measuring from 100 to 150 feet, and the percentage of quartz present are considered, it means the breaking down of a large mass of crystalline rocks to furnish the material necessary to build up such a deposit. The igneous rocks in the average contain about 12 per cent of quartz.[1] The crystals in only a small part of this 12 per cent are as large as the sand grains and pebbles in the conglomerate. Further there was a large loss of coarse material through internal strains, which fractured the crystals into parts, and through the abrasion which was necessary to round the particles to the state of the conglomerate sand grains and pebbles. The volume of the Sharon conglomerate, under any consideration, must be multiplied by a very large factor to obtain the original mass of crystalline rocks from which its material was derived.

The lapse of time represented by the transition of quartz crystals from the igneous rocks to the rounded sand grains and pebbles of the Sharon conglomerate was also relatively great, for the elimination of associated minerals through chemical and physical agencies, could only be accomplished through long continued action. The character of the conglomerate suggests the work of two potent factors, the first of which is that of disintegration or rock decay, and the second that of differential sorting and deposition of the various liberated components, but both more or less active contemporaneously.

When a rock is exposed to atmospheric agencies it undergoes a partial decomposition and becomes gradually disintegrated. Some of its substance is dissolved by percolating waters, themselves of atmospheric origin, and is so carried away; the remaining material, partly hydrated and partly unchanged in composition, contains products which are easily separated from one another. The breaking down of a rock is effected partly by mechanical and partly by chemical means. Mechanical agencies, such as the grinding power of glaciers, the pounding of waves, erosion by streams, the dis-

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[1] F. W. Clarke, Bull. 491, U. S. G. S., p. 398.

> ruptive effects of frost or the action of wind-blown sand, tend to separate the particles of a rock and to furnish fresh surfaces to chemical attack. Unequal expansion, due to alternations of heat and cold, also assists in producing disintegration. Solution, hydration, disintegration, and mechanical sorting are the successive stages of rock decay.[1]

The important magmatic minerals, such as feldspars, micas, pyroxenes, amphiboles, olivine, leucite, nephelite, pyrite, apatite, and titanium compounds, are attacked by the various chemical and physical agencies with ultimate disintegration of the original rock. Quartz, which is quite insoluble, and thus but little affected by the ordinary agencies, is left practically unchanged.

> By solution, oxidation and hydration, then, a solid rock is converted into an aggregate of loose material, which may remain in places as soil or be removed by the mechanical agencies of running water. As a rule the chemical processes are incomplete; some of the minerals are not entirely altered, and the loose products therefore exhibit many variations. In general terms, the streams separate the disintegrated materials into coarser and finer or lighter and heavier portions. The clay-like substances are generally light and finely divided, and therefore remain longest in suspension. The heavier sands and gravels are not carried so far, and thus a separation is effected. In these coarser portions are found quartz, together with undecomposed portions of various minerals; the lighter silts are less variable in composition.[2]

The composition of the Sharon conglomerate shows that the disintegration of the magmatic rocks, and the mechanical separation of the altered integrants from the more resistant quartz, were quite complete before final deposition. The original materials may have passed through many alternating cycles of chemical action and mechanical separation before the final deposition of the conglomerate. This is favored by the high percentage of quartz, requiring practically complete rock decay, and by the well rounded forms of the particles, requiring long continued or severe abrasion. If the materials in the conglomerate came direct from the parent rocks, we would expect during a time interval of short duration, a mixture of minerals and more angularity of the particles. The Sharon conglomerate thus appears to be the final product of various forces acting slowly but continuously.

What became of the associated materials is the question which next arises, since the quartz in the Sharon conglomerate constitutes only a small fraction of the total matter in the original crystalline rocks, from which it was derived. In the disintegration of magmatic rocks by solution, hydration, oxidation, and mechanical means, while the quartz is very resistant and but little affected, the associated minerals are altered to a variety of powdery or fragile minerals, or broken up into fine parts; for example, feldspars give kaolinite, micas alter to soft secondary products or break along the cleavage planes into thin plates, and ferro-magnesium minerals give a variety of products usually low in the scale of hardness. When prolonged these forces thus tend to increase the difference between the average sizes of quartz particles and those of the alteration products of the other original integrants.

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[1] F. W. Clarke, Bull. 491, U. S. G. S., p. 452.

[2] F. W. Clarke. Bull. 491, U. S. G. S., p. 458.

During transportation the coarse materials continually lag behind the finer products, so, applying this to the disintegration products of magmatic rocks, the quartz would be the lagging component. If the rocks decayed on the land, the fine alteration products would be carried farther by the rains, rivulets, and streams than the coarse unaltered quartz; if the breaking up occurred along the sea shore the finer materials would be carried far out into deep or quiet waters, while the coarse material would be left within the zone of wave action, or along the courses of strong currents. Due to the extreme hardness of quartz it is only slowly reduced by abrasion forces, but many associated minerals are easily ground to rock flour. The finer minerals would be the first to reach the sea, and the first to be carried away by moving oceanic waters. If the breaking up of the rocks occurred far inland, especially where the stream gradients were low, the finer materials would reach the sea far ahead of the coarse quartz. Sluggish streams would not transport the latter. If the beach line remained nearly stationary, and the shore not swept by strong currents, the distribution of the quartz would be local, but the finer materials widely scattered. The sedimentation of this fine material would form shales and shaly sandstones, such as make up the Mississippian rocks.

The pebbles in the Sharon conglomerate are all highly abraded. In the main they are well rounded, indicating that the abrasion was produced through rolling action of currents, but some are flattened, indicating shore action. The cross-bedding of the stratum, highly pronounced, also indicates current action. Considering all points, the history of the Sharon conglomerate seems to indicate that the decay of the crystalline rocks reached an advanced state on low lying uplands; that the products were slowly transported to the sea, coarse materials lagging far behind the finer products; that the fine materials were distributed to the deep and quiet waters, forming shale, while the coarse materials were left more localized along the margins; that a general elevation took place, converting much of the floor of the sea to land, and restricting the currents to narrow shallow passages; that the force of these currents was now sufficiently strong to transport the coarse quartz, and thus build up the conglomerate. It represents the final act of a series of agencies, which includes rock decay, transportation, selection of material, crustal forces, and final deposition.

A few general sections showing the thickness and character of the Sharon conglomerate, and its relation to other members, will be given. The upper part of the Sharon conglomerate, with the Sharon coal, which has been mined for local use, and the Sciotoville clay above, is exposed on land of Jacob Fraser, in Section 19, Union Township. The following measurements were obtained:

	Ft.	In.
Clay, flinty, *Sciotoville*	1	--
Covered	30	--
Coal, *Sharon*	2	--
Clay and covered	3	--
Conglomerate, pebbly, *Sharon*	20	--

From the forks of the road on Gravel Hill, in the southeast corner of Section 19, to the ridge west, there is a rise in the upper surface of the conglomerate of about 50 feet in one-fifth mile. The roll or sudden change in the elevation of the upper surface is similar to that noted at a number of places in Jackson and Scioto counties. Near the head of Andrew Hollow the conglomerate measured 60 feet in thickness; the lower part is made up of pebbles, loosely cemented, but the upper part is a coarse-grained sandstone, with only occasional pockets of pebbles.

The rocks exposed along the road up Gravel Hill, in Section 29, Marion Township, gave the following measurements:

		Ft.	In.
Coal blossom, *Sharon*, seen north of road		2	--
Sandstone, coarse-grained, red and yellow colored, with occasional pebble layers	*Sharon* conglomerate	22	--
Sandstone, soft, light, with scattered pebbles		23	--
Sandstone, hard, with scattered pebbles and thin pebbly layers		25	--
Sandstone, shaly, *Logan*		5	--

The following section was taken along the road that leads from McDowell Creek to the ridge south in Section 27, Marion Township:

		Ft.	In.
Ore, nodular		--	2
Clay, flinty, dark, oolitic structure	*Sciotoville*	1	--
Clay, dark red and mottled," pink eye"		9	--
Conglomerate, very pebbly, *Sharon*		20	--

On land of Henry Bapst, in Section 26, Beaver Township, the relation of the conglomerate and coal above is as follows:

	Ft.	In.
Shale	10	--
Coal, *Sharon*	2	6
Clay, light, siliceous	2	--
Conglomerate, *Sharon*	12	--

Along the road south of the home of J. W. Overly, Section 2, Jackson Township, the rocks exposed measured as given below:

		Ft.	In.
Coal, *Sharon*		2	4
Clay, siliceous		1	--
Sandstone, light, plant marked, argillaceous	*Sharon*	5	--
Sandstone, with pebbly layers		75	--
Conglomerate, made up of pebbles with a few sandy layers, loosely cemented		60	--
Shales and argillaceous sandstones, *Logan*		65	--

West of this, on land of Willis Hartley, a conglomerate was also seen above the Sharon coal, which condition was noted in many localities in Pike and Jackson counties. The rocks here measured as follows:

		Ft.	In.
Shale, with thin sandstone		--	6
Coal, bony	*Sharon*	--	1
Coal, good		2	1
Coal, usually bony		--	2
Clay, siliceous		1	--
Covered		5	--
Conglomerate, *Sharon*		80	--

Along the road west of the above, both the coal and the upper surface of the conglomerate rise 18 feet in about 100 feet. The Sharon conglomerate also thins going westward. In the same section, south of Allen Chapel, on land of Samuel Graw, the following rocks were exposed:

	Ft.	In.
Sandstone, with pockets of quartz pebbles, which are of practically the same size as those in the conglomerate below	18	--
Coal, *Sharon*	2	6
Clay	1	--
Covered	9	--
Conglomerate, pebbly, *Sharon*	30	--

The rock above the coal is very similar to the true conglomerate below, in composition and texture, excepting that it contains fewer pebbles. The coal may be said to lie in the Sharon conglomerate. North of Allen Chapel, on land of Joseph Hartley, the Sharon coal is wanting, but the Sciotoville flint clay is found along the roadside lying above the conglomerate. A section taken here follows:

	Ft.	In.
Clay, flint, good quality, *Sciotoville*	2	--
Conglomerate, upper part sandy	59	--

In the northwest corner of Section 31, on land of Jasper Bowman, the following strata were measured:

	Ft.	In.
Coal, *Sharon*	2	1
Covered	3	--
Conglomerate, *Sharon*	60	--

Extent and General Character

The Sharon conglomerate, varying from a coarse-grained sandstone to a very pebbly conglomerate, and from 10 to 70 or more feet in thickness, is quite persistent throughout Marion Township. In the eastern part of the township the upper surface of the conglomerate is found at an elevation of about 880 feet, while in the western part it is about 950 feet. In Union Township the conglomerate is found near the summits of the high hills and ridges east of Pecks Creek. The high knobs on the main ridges between Owl Creek and Dutch Run, and

Dutch Run and the Beaver Creek Valley, are capped with conglomerate, which varies in thickness from 10 to 60 feet. Where the deposits are thick the lower part is usually very pebbly, while the upper part is practically a coarse-grained sandstone. The deposits are found above the 1,000 foot contour. The conglomerate was noticed on one hill only in Scioto Township. Pine Knob, in Section 9, is capped with about 30 feet of pebbly conglomerate. The fragments indicate a continuous sheet of conglomerate in this area, which was cut away by erosion, leaving patches on the high places and ridges only.

In the northeastern part of Beaver Township the Sharon conglomerate is massively developed, but south of this it thins or is wanting. In the central part of the township it is usually wanting, but where present it is represented by coarse-grained sandstones seldom more than 20 feet in thickness. In the western part of the township it is found on a few knobs only in the vicinity of the Rock Spring School, where it measured 45 feet in thickness. The upper surface of the conglomerate here has an elevation of about 1,020 feet. The conglomerate was found in Seal Township only on two hills, which are in Section 20. On one only loose blocks were seen, but on the summit of the other hill there is about 10 feet of the stratum in place. Here it is made up of loosely cemented pebbles, some of which are 2 inches in diameter. The elevation of the deposit is about 1,120 feet above the sea. In eastern Jackson Township the Sharon conglomerate is massively developed, the thickness often reaching from 100 to 150 feet. The elevation of the upper surface, marked by the outcrop of the Sharon coal, is approximately 950 feet. In the northern part the stratum extends westward to the Scioto Valley. Chimney Rocks are composed of conglomerate, the total thickness of which here is about 70 feet, and the elevation of the upper surface of which is about 1,100 feet. The main ridge between Hickson and Mutton runs is made up of massive conglomerate, while four high knobs have the sandstone above the horizon of the Sharon coal. Between Mutton Run and Hay Hollow the conglomerate is usually present on all the hills and ridges that extend above the 900 foot contour. The stratum on the high knob in the southwestern part of Section 24 measured 50 feet in thickness. The lower part is composed of coarse pebbles, loosely cemented, but the upper part is more sandy and contains only small pebbles. In Section 25, on L. T. Johnson's farm, the deposit, some 70 feet in thickness, shows 20 feet of very coarse material at the base, with 50 feet of sands containing smaller pebbles above. The same condition holds true also for the deposit noted on land of James Hartley, in Section 16. The high places on the main ridge between Hay Hollow and Jackson Run also contain heavy deposits of Sharon conglomerate, which measure from 40 to 90 feet in thickness, and vary in composition from coarse sandstone to coarse conglomerate. The elevation of the highest part exposed is about 1,020 feet. No conglomerate was noted on the ridges between Jackson Run and Cars Run, although the elevations of some of the high hills are above those to the north which contain conglomerate. The bed is wanting, because on a few knobs the sandstone above the horizon of the Sharon coal is present. The rocks making up the main ridges are Mississippian shales and sandstones. West of Cars Run no conglomerate was seen on the ridges, excepting on the high hill facing the Scioto in Section 4. This knob, capped with about 15 feet of conglomerate, has an elevation of only 920 feet, while many ridges and hills south, made up entirely of Mississippian rocks, rise from 1,000 to 1,100 feet above tide.

Economic Value

The Sharon conglomerate in Pike County has been used for many years for local purposes, but it has never been prepared for the market. The gravel from the conglomerate is the common road facing used in the eastern part of the county, for limestone and other hard rock are wanting. The conglomerate is widely distributed and the gravel easily obtained from the loosely cemented pebbly layers by plowing, picking, or shooting. The material, when composed largely of pebbles requires some time to thoroughly pack, but it then makes a good solid surface. If mixed with sand, or a small amount of clay, it packs more quickly and wears better. From this material good roads may be made at a low cost. This gravel withstands the wear from heavy traffic better than the glacial gravel from the Scioto River, which is also used locally for road purposes. The gravel from the Sharon conglomerate is used, to a small extent, for concrete work, such as walks, culverts, foundations, and silos. It is quite free from clay, rock flour, or fragile material, but the pebbles and sand grains lack angularity, which gives an interlocking structure. On the whole the material makes a concrete with sufficient strength for all ordinary purposes.

The best economy would be obtained by sizing the material first, then proportioning each size to that amount required to give body and to fill the voids. For concrete work in general, this gravel cannot compete with the more accessible glacial gravel found along the Scioto River, although the former is of much better quality. The coarse pebbles are suitable for decorative concrete work, as their rounded forms and light colors are attractive. For concrete work the sand from the Sharon conglomerate is also superior to that found along the Scioto River, as the latter contains a much larger amount of fine or silty material and fragile particles, due to the decay of mineral components.

This gravel, crushed and properly sized, would make an excellent sand-blast abrasive. for on account of the hardness of the quartz, and the sharp edges produced by breaking, its cutting power would grade high, and the material would not be easily worn out, but could be used a number of times. The crushing of the gravel would not be extremely difficult, as the pebbles are more or less fractured from expansion changes. Crushed gravel is also used in a small way for a number of minor purposes.

Commonly, a part of the Sharon conglomerate, and in some localities, the entire stratum, is made up of sands which contain at most only scattered pebbles or small pockets of gravel irregularly distributed. These sands, containing but little kaolinite, mica, or other aluminous minerals, are generally stained with iron oxides. In some deposits, locally, the latter component is also low, and there the crude sands are of glass sand quality, but they seldom reach the composition of the highest grades, although, if carefully selected and washed, very pure material may be obtained. The impure sands alone are usually somewhat lacking in bonding materials for general molding purposes, but, if mixed with a small amount of argillaceous sand, they make good strong forms. The crude sands are well suited for pig beds or open casting work. In Pike County, the Sharon conglomerate has not been worked for general shipment, as the deposits are not favorably located with reference to the present railroads. The contemplated extension of the Chesapeake and Ohio Railway will make available some of the deposits in Union and Jackson townships. Evidently, due to the variety of materials that may be produced, these deposits will be of some considerable importance in the future and should be considered an asset, especially when favorably situated.

SHARON, "JACKSON SHAFT" OR No. 1 COAL

The Sharon and Anthony are the only coals represented in Pike County, and only the former has a thickness sufficient for mining. The area in Pike County forms the western margin of the Jackson field, and the stratum, with but few wants, may be traced, excepting where cut away by erosion agencies, directly to the town of Jackson, where it was first mined. Also from Beaver and Jackson townships the bed may be traced eastward to the Quakertown or Wellston coal field in Jackson County. Its northward extension into Ross County is represented by a few thin or bony deposits, found on the main ridge south of Peters Cave in Jefferson Township. The small field in Marion Township is also correlative with that in Madison Township, Scioto County. The Sharon coal, in Pike County, is of interest for its relation to the Sharon conglomerate, and for the local supply of fuel which it furnishes.

Stratigraphy

The Sharon coal may be defined in a general way as the first coal stratum above the Sharon conglomerate. Yet this does not always hold true, for, in some localities, a thick conglomerate is found above the coal, while in other localities the conglomerate is wanting below the coal; and, at a few places noted elsewhere, the Sciotoville clay with the Anthony coal above, lies on the conglomerate. The stratum is marked by irregularity of deposition. The upper surface of the Sharon conglomerate is very uneven, and the coal stratum lying close to this floor, is subject to many dips and rolls. It also varies greatly in thickness and composition. A 3 foot bed in a short distance may change to bone coal and carbonaceous shales, thin to a few inches, or be replaced completely. The bed is made up generally of one coal bench only, but this may have one or more bony partings. Normally, the Sharon coal lies from 30 to 40 feet below the Sciotoville clay, but this interval is subject to great variation. In Jackson County, at the abandoned Star Furnace mine, the clay in local areas forms the roof of the coal. The Sharon coal usually lies from 70 to 80 feet below the Quakertown coal, but the latter bed was not observed in Pike County. The structure of the stratum and its relations to other members will now be discussed.

Marion Township.—In Section 28, Marion Township, on land of Josephine McClain, west of the Stockdale-Beaver pike, the Sharon coal was formerly mined for local use. The section obtained is as follows:

	Ft.	In.
Shales, sandstones and covered	50	--
Coal, *Sharon*	1	10
Covered	5	--
Conglomerate, *Sharon*	9	--

The coal here is reported to vary from 1 foot 8 inches to 2 feet 4 inches in thickness. On the northern line of this section, near the home of Earl Brown, the blossom of the Sharon coal was seen in the road. To the west and north the Sharon conglomerate rises fast, the Sharon coal is wanting, and the Sciotoville clay, both flint and "pink eye," was seen only a few feet above the conglomerate. The roll here in the conglomerate cuts out the coal. The Sharon coal was formerly mined for local use on land of John Swartz on Gravel Hill, Section 29. The coal is reported to have a thickness of from 2 feet to 2 feet 4 inches. A composite section taken there follows:

		Ft.	In.
Shale and covered		30	--
Coal, *Sharon*, reported thickness		2	4
Covered		9	--
Sandstone, hard, coarse-grained, with pebbly layers near top, part colored red	*Sharon* conglomerate	22	--
Sandstone, soft, with scattered pebbles		23	--
Sandstone, with thin pebbly layers and scattered pebbles		25	--
Sandstone, shaly, *Logan*		5	--

On land of G. W. Vanfossen, in Section 20, the Sharon coal was formerly mined along the outcrop. The stratum is reported to vary from 1 foot 8 inches to 2 feet 4 inches. The quality of the coal is very good. Along the road in the northeastern part of the same section a heavy blossom of the Sharon coal was seen. The floor of the bed is massive, pebbly Sharon conglomerate and the roof a heavy sandstone. North of this in Section 17, on land of B. F. West, the bed, which has been worked in a small way, is reported to average about 2 feet in thickness. The roof is shale. In Section 15, along the road near the home of Fred Keppler, the blossom of the Sharon coal was seen above the massive conglomerate. In the well at this house, Mr. Keppler reports 2 feet 6 inches of stain. The coal in this region is probably rotten as the cover is shallow. In Section 14, near the home of John Lyons, thick exposures of Sharon conglomerate were seen. Mr. Lyons reports that there is a thick blossom of coal lying just above this, but it has not been prospected.

Union Township.—In Union Township, the Sharon coal was seen only on Gravel Hill, although there are other places with rock stratigraphically above the Sharon conglomerate. Coal for local use was mined for several years on the land of Jacob Fraser on Gravel Hill, in Section 19. The rocks measured there are as given below:

	Ft.	In.
Clay, flinty, *Sciotoville*, seen on outcrop	1	--
Covered	30	--
Coal, *Sharon*	2	--
Clay and covered	3	--
Conglomerate, *Sharon*	20	--

Here the coal is reported to have a thickness ranging from 1 foot 8 inches to 2 feet 4 inches. From Gravel Hill to the next ridge west the Sharon conglomerate rises about 50 feet, and the coal is probably wanting, for it was not found or reported. There are a few points west of Pecks Creek, also, with rocks above the Sharon conglomerate, but no coal was seen.

Beaver Township.—There is a small area of Sharon coal in eastern Beaver Township, although in part of this the bed is thin or bony. In Section 26, on land of Henry Bapst, the following rocks were exposed:

	Ft.	In.
Shale	10	--
Coal, *Sharon*	2	6
Clay, light, siliceous	2	--

On the main ridge north of this the blossom of the Sharon coal was seen at several places, but no good sections were obtained. The coal is patchy and generally thin.

Jackson Township.—The most productive area in Pike County is in eastern Jackson Township, where the coal has a fair average thickness, and is rather persistent. Coal for local use has been mined for many years, and the supply is far from being exhausted. The section of a mine on land of George Leist, Jr., in Section 14, is as follows:

	Ft.	In.
Shale, blue	10	--
Coal, *Sharon*	2	8
Clay, light, sandy	1	--

The Sharon coal was opened on land of J. W. Overly, in Section 2. Mr. Overly reports the thickness, where opened, to be from 2 feet 4 inches to 2 feet 6 inches, and the coal of good quality. The section taken along the road south of his home is as given below:

	Ft.	In.
Shales and covered	21	--
Coal, *Sharon*	2	4
Clay, siliceous, light	1	--
Conglomerate, *Sharon*	140	--
Sandstones and shales, *Logan*	65	--

Coal has been mined for local use on land of Willis Hartley for many years. Here there is a pebbly sandstone above the coal, which is quite similar in character to the conglomerate below. On the outcrop there was only 8 feet of conglomerate exposed, but Mr. Hartley says in the hill this has a thickness of 20 feet. The shale or draw slate above the coal is also reported to be wanting under heavy cover. The section taken shows the following relations:

		Ft.	In.
Shale		--	6
Coal, bony	*Sharon*	--	1
Coal, good		2	1
Coal, usually bony		--	2
Clay, siliceous		1	--
Covered		5	--
Conglomerate, *Sharon*		80	--

Along the road in the western part of the same section the coal rises about 15 feet in approximately 100 feet. The section measured is as follows:

	Ft.	In.
Sandstone	2	--
Coal blossom, *Sharon*	1	6
Clay, siliceous, hard	2	--
Internal coal rises	16	--
Conglomerate, *Sharon*	75	--

South of Allen Church, on land of Samuel Graw, the Sharon coal with the heavy conglomerate above is exposed at the old mines near his home. The section taken follows:

	Ft.	In.
Sandstone, massive, interbedded, with scattered pebbles and thin gravel layers, resembling the conglomerate below the coal. May be called a conglomerate	18	--
Coal, part somewhat bony, *Sharon*	2	6

	Ft.	In.
Clay	1	--
Covered	9	--
Conglomerate, massive, sandy, *Sharon*	30	--

In the southern part of Section 3, on land of J. D. Walker, the Sharon coal is being mined for local use. The thickness is reported by Mr. Walker to vary from 1 foot 5 inches to 2 feet 6 inches, but to average about 1 foot 8 inches. The quality of the coal is very good The pebbly sandstone or conglomerate was seen above the coal here also. The following are the measurements of the rocks exposed:

	Ft.	In.
Sandstone, coarse-grained, irony, with pebbles	4	--
Shale	--	3
Coal, *Sharon*	1	8
Clay, hard, siliceous, flinty	1	--

In the northern part of the same section, on land of John J. Irwin, the coal was once mined. The section obtained follows:

	Ft.	In.
Shale, with thin sandstone layers	10	--
Coal, *Sharon*, reported thickness	2	4

West of this, on the high knob in Section 4, the sandstone with pebbles found above the horizon of the Sharon coal is about 60 feet in thickness. It lies directly on the conglomerate, which is also very thick and very pebbly.

In Section 31, just north of Allen Chapel, the Sharon coal is wanting, but the Sciotoville clay lies on the conglomerate, or the pebbly sandstone above the horizon of the Sharon coal. No distinct line of disconformity was noted between the two conglomerates. The section taken follows:

	Ft.	In.
Clay, flint, good, *Sciotoville*	2	--
Conglomerate, *Sharon*	59	--

North of this, on the Isaac Wickline farm, coal has been mined for a number of years, and the thickness is reported to vary from 2 feet 4 inches to 2 feet 6 inches. The following section was obtained at the mines:

	Ft.	In.
Sandstone, bluish, closely stratified	6	--
Coal, good } *Sharon*	2	6
Coal, bony, } *Sharon*	--	4
Clay.		

The section taken on land of M. G. Grover, north of Wickline, shows he massive sandstone above the coal. The record follows:

	Ft.	In.
Sandstone, massive, coarse-grained	22	--
Coal, *Sharon*, reported thickness	2	4

On the northwest corner of Section 31, on land of Jasper Bowman, the coal has been mined for local use. The bed here is reported to vary in thickness from 1 foot 6 inches to 2 feet 2 inches, and to average about 1 foot 8 inches. The heavy sandstone stratum is found above the coal, but in places shale, varying from a thin parting to 3 feet, separates the two. The following rocks were exposed for measurement:

	Ft.	In.
Shale	--	2
Coal, *Sharon*	2	1
Covered	3	--
Conglomerate, *Sharon*	60	--

In Section 30, on land of W. H. Sprague, the stratum is made up of bone shales with thin coal bands, while along the ridge northwest of this the coal is wanting. The section taken near Mr. Sprague's house is as given below:

	Ft.	In.
Sandstone, coarse-grained, with some pockets of quartz pebbles	21	--
Bony shales, with thin coal layers, *Sharon*	3	--
Clay	1	--
Covered	4	--
Conglomerate, massive, *Sharon*	30	--

The following rocks were exposed at the mine of James Maple & Son, in Section 22:

		Ft.	In.
Shale		6	--
Coal, good	*Sharon*	2	6
Coal, bony, in places wanting		--	2
Clay, blue, siliceous		1	--

In Section 22, near the home of Peter Lew, Jr., coal is mined for local use. The stratum is reported to have a thickness of from 1 foot 10 inches to 2 feet 8 inches. The bed shows irregularity of deposition, for there is a dip of 20 feet to the north in about 100 yards. The blossom of the coal was seen at a few places along the ridge north of this in Section 19, but, as the cover is shallow, it has not been worked. In the northwest corner of this section the rocks exposed were as follows:

	Ft.	In.
Sandstone, coarse-grained, with fine and coarse pebbles	45	--
Horizon of *Sharon* coal, noted just east.		
Conglomerate, *Sharon*	45	--
Sandstone, fine-grained, with some shales and parts covered	80	--
Shales, with sandstone layers, and *Logan*, parts covered	70	--

On the high point near Chimney Rocks there are about 75 feet of strata above the horizon of the Sharon coal. The blossom of the coal was not seen. West of the main ridge in eastern Jackson Township, which is the productive area, the coal seems to be very thin or completely wanting, although there are many hills above the horizon. On some of these the Sharon coal is replaced by the heavy sandstone above, which lies directly on the conglomerate. On some, both the Sharon conglomerate and coal are wanting, and the rocks near the horizon of the Sciotoville clay are in contact with the Logan sandstone or shales.

Economic Value

The estimated area of the small field in Marion and Union townships is only about 400 acres, of which, from surface indications, not more than 60 per cent is productive territory; while the area of the large field in Beaver and Jackson townships is approximately 2,000 acres of which, judging from the distribution of the mines, about the same per cent is productive. The total area in Pike County, in which the Sharon coal has sufficient thickness and cover for mining, is approximately 1,400 acres. Due to the uncertainty of the bed this estimate may be somewhat high. The coal for many years has contributed a part of the local fuel supply. On Allen Ridge it is the main reliance. Although the coal has been drawn from a part of the productive area, the supply yet available is ample for local wants for many years. So far the mining has been done in a rather haphazard way, for the mines are worked usually only a few months during the fall and winter. The method usually followed is single entry with side rooms, little provision being made for ventilation or drainage. The coal cars are pushed by hand. The system used admits only of mining close to the outcrop, so the main bodies of the coal are yet untouched. The area and thickness of the bed, with the limited fuel demand, are not sufficient to warrant operation on a large scale. The bed varies in composition and structure in much the same way as in the Jackson field. In some localities it is made up of quite pure coal, in others of rough bony coal, and in others of black bony shales with thin coal bands. The coal averages rather high in ash, which is light colored and powdery, but low in sulphur. It has a good solid structure and a bright color. It burns readily and has good heating power. On the whole the bed is of importance for a local fuel supply.

The sandstone which is found above the Sharon coal in a part of this region, and which in places is very pebbly, having all the characteristics of a true conglomerate, is of interest. The pebbles in this sandstone are similar in composition and shape, but average somewhat smaller in size than those in the true conglomerate below, both evidently derived from the same original source. It is questionable whether this pebbly sandstone should be considered a part of the Sharon conglomerate, although in some localities the two are quite alike in structure and general appearance. The Sharon conglomerate varies from a very coarse-grained pebbly conglomerate to a medium fine-grained sandstone, and this sandstone above the coal has the same al phases, but the pebbles are only medium sized and confined usually to thin layers near the base of the deposit, or are distributed irregularly throughout the mass. This sandstone is pebbly only in local areas, while the Sharon conglomerate generally contains more or less coarse material. Pebbles are common also to strata higher in the Coal Measures, notably, the Guinea Fowl ore, the sandstone below the Quakertown coal, and that above the Lower Kittanning coal. The time interval between the deposition of the Sharon conglomerate and this sandstone was of sufficient duration to allow the deposition of the Sharon coal, and in some localities a few feet of shales and shaly sandstone. In the localities where the intervening coal and shales are wanting, as a general rule, there is a well-defined disconformity between the two deposits, but at some places no separation was evident. The deposition of the coal and shales involves elevation changes or restriction of current action. In this sandstone, a part of the material, including the coarser pebbles, may have been derived also through erosion from land masses of conglomerate, the existence of which, during this period, is indicated by the pronounced disconformity noted in localities to the south, where the conglomerate extends into the upper measures to the horizon of the Sciotoville clay. The evidence points more to similarity of conditions during deposition—the same as existed during the formation of the coal beds—than to a direct relation between the two deposits. In the opinion of the writer, the pebbly sandstone deposits above the Sharon coal should not be considered a part of the Sharon conglomerate.

SHARON IRON ORE

Only a few small pockets of ore, which were placed with some confidence on this horizon, were found in Pike County. In Section 23, Marion Township, on land of W. M. Lyons, ore was formerly mined for the Star Furnace Company, Jackson, Ohio. Mr. Lyons reports the stratum to vary in thickness from 4 inches to 1 foot 6 inches, and the ore to be of good quality compared to other native ores. The ore was mined by stripping. Here the Sharon conglomerate is wanting and the stratum lies close to the Logan sandstone. No section was obtained, as the strata were more or less covered when the region was visited. The same ore was also mined for the same company south of this on lands of William Ehrman and G. W. Keller. Here the stratum is reported to have a thickness of from 10 inches to 1 foot 6 inches, and the quality to be the same as that on the Lyons property. This ore was also exposed along the road in the southern part of Section 3, Jackson Township. Here it lies close to the Sharon conglomerate which is massively developed. The value of the deposits is small.

SCIOTOVILLE CLAY

The Sciotoville clay is seldom present in Pike County, although many knobs in the eastern part rise above this horizon. In part of the area the clay is replaced by massive sandstones, but even where the strata are mainly shales the member is seldom present. In Section 19, Union Township, on land of Jacob Fraser, the Sciotoville clay was seen well above the Sharon coal. The relation of the Sciotoville clay to that of the Sharon coal and conglomerate below is about normal. The section taken on this land is as follows:

	Ft.	In.
Clay, flinty, *Sciotoville*, seen on outcrop only	1	--
Covered	30	--
Coal, *Sharon*	2	--
Clay and covered	3	--
Conglomerate, *Sharon*	20	--

In Section 28, Marion Township, on land of Earl Brown, pieces of good quality flint clay with a heavy "pink eye" clay below were seen on the outcrop. Here the Sharon conglomerate shows a decided roll; the clay lies close to the crest of this and the Sharon coal in the trough to the east. Along the road that leads from the ridge to McDowell Creek, in Section 27, the clay was seen also lying close to the conglomerate. The Sharon coal here is wanting. The rocks exposed are as given below:

		Ft.	In.
Ore, nodular		--	2
Clay, dark, flinty, oolitic structure	*Sciotoville*	1	--
Clay, "pink eye," part very red		9	--
Conglomerate, very pebbly, *Sharon*		20	--
Covered		10	--
Sandstones, shales and parts covered, *Logan*		60	--

North of Allen Chapel, in Section 31, Jackson Township, on land of Joseph Hartley, an exposure of very good flint clay was seen. It lies close to a conglomerate, the upper part of which appears to be the same as the pebbly sandstone or conglomerate found above the Sharon coal just south of Allen Chapel. The section recorded is as follows:

	Ft.	In.
Clay, flint, good, *Sciotoville*	2	--
Conglomerate	59	--

The Sciotoville clay in Pike County has practically no economic value, for the deposits are small, widely scattered, and far from transportation facilities. The quality of the clay observed on land of Joseph Hartley is very good, but the territory apparently small. These deposits are of interest stratigraphically, for they form connecting links in the chain of deposits extending northward from the Scioto County fields to those in Vinton County, and they also show the wide distribution of the Sciotoville clay.

ANTHONY COAL

The Anthony coal lies just above the Sciotoville clay, but in Pike County only a thin stain or blossom was noted, and that in but two ties.

SANDSTONE NEAR HORIZON OF SCIOTOVILLE CLAY

The sandstones near the Sciotoville clay horizon in some localities are quite pure, approaching glass sand quality. They were noted especially in eastern Marion Township. On the high hill near the line of sections 27 and 28 the deposit measured 12 feet in thickness. The sandstone there is light colored, rather fine-grained, and quite free from clay, mica, or iron minerals. It is used locally for foundation and bridge stone. It appears to correlate with the sandstone observed near Glade in Jackson County.

ITEMS OF GENERAL INTEREST

Springs

The large number of perennial springs in the regions where the Sharon conglomerate is well developed are of interest, as they afford an ample supply of very pure water for both man and beast. In this respect there is a marked contrast between these regions and those where the rocks are Mississippian shales and sandstones, for, in the latter, constantly flowing springs are few, and the waters of these generally poor. These springs usually issue from near the base of the conglomerate, which, as previously described, forms many bold cliffs and gorge-like valleys. In the heat of the summer, around those springs, especially when sheltered by the cliffs and trees, are found cool retreats for the live stock. Many of the springs have a strong flow of water, and issue well above the valley plains, so that irrigation in a small way may be carried on during the dry summer months, cheaply and profitably. Their value for truck gardening is worthy of consideration.

Fruit Lands

The high sandy ridges, especially in the regions where the Sharon conglomerate is prominent, are excellent fruit lands. The trees, when given proper attention, bear abundantly, and the fruit is highly colored and of excellent quality. Orchards on this ridge land may be cultivated and sprayed with ease. The conditions for marketing at present are somewhat unfavorable, but with the extension of good roads into the hilly regions these conditions will be improved. There is also some good fruit land in the old preglacial river valleys in eastern Pike County. The parts best suited are the high terraces and those on the main plains, which are well drained by small streams. The areas that are swampy, or have a hardpan close to the surface should be avoided.

A few small but very good orchards are found in the old Teays River Valley a few miles east of the Scioto River. The largest orchard in the region, however, is located in the valley of the Portsmouth River, about 1 mile east of Wakefield. The owner, W. W. Tibbals, kindly gave the following information concerning it: "The farm, which consists of 186 acres, is located on the top of a ridge, which has an elevation from 800 to 850 feet above tide. More than 100 acres are as level as the land in the Scioto bottoms. From this level tract the land slopes to valleys on the north, south, and west; hence it has natural conditions favorable for perfect air and water drainage. The orchard covers a territory of 80 or 90 acres, and consists of about 11,000 peach trees, the main varieties of which are Carmen, Belle, Elberta, Old Mixon, Stump of the World, Chairs Choice, Smock, and Salway.

"Modern methods have been employed in caring for the trees from the beginning. The trees are headed low; hence more than 75 per cent of the fruit is gathered without ladders. The trees are sprayed from one to three times each year, which keeps them in good condition. The entire orchard has been cultivated from the time the trees were set. During May or June the ground is either plowed or disked. It is then harrowed frequently until late in July. Cow peas are then sown for a cover crop and for soil enrichment. The trees are very thrifty and the fruit produced is large and perfect. The fruit ripens just between the southern crop from Georgia and the northern crop from Michigan; hence it ripens at a time when fruit commands good prices. With the modern methods of orchard heating and smudging a crop failure seldom occurs. Considering the low price at which undeveloped land in Pike County is valued, I consider this an excellent territory for an investment of this kind."

CHAPTER IV

EASTERN HALF OF SCIOTO COUNTY

Importance of the Area

This county is of special interest for its ceramic products. The manufacture of fire brick began in 1864, and the business has remained prosperous, as the ware enjoys a good reputation and a wide market. This region is also one of the recognized centers of the paving brick industry of the State. For years the charcoal iron furnaces were important, but these have been dismantled. The ores, coals, and limestones have but little economic value, but the vast wealth of clays and shales indicates a bright future for the established ceramic industry.

Location and Area

Scioto County lies in the southern part of the State on the Ohio River, which thus forms its southern boundary. It is bounded on the east by Lawrence and Jackson counties, on the north by Pike, and on the west by Adams. The area of the county, according to the latest government estimate, is 640 square miles. That part of Scioto County east of the Scioto River only will be treated in this bulletin.

Topography

RELIEF

The surface of Scioto County has been extensively modified, both by the present streams and by preglacial streams. The region is rough and broken, except the flood plains of the Ohio, Scioto, and the preglacial Teays rivers. The flood plain of the Ohio along Scioto County is generally narrow, but that of the Scioto averages from one and one-half to three miles. A preglacial stream (Teays) ran northward across the county through the California Valley from the present Ohio Valley near Wheelersburg into Pike County near the village of California. This old valley is from one to two miles wide and very level, excepting that part from Wheelers Mills, south, which has been dissected by the Little Scioto, and left notably terraced. The flood plain of the Little Scioto, north from where it enters the California Valley at Wheelers Mills, is usually very narrow, seldom exceeding one-fourth mile in width. The Pine Creek Valley in Scioto County averages about one mile in width along the lower course, but narrows to one-half mile in Vernon Township. That part of the county that lies between the Scioto and the California valleys is exceptionally broken and rugged, as it has been dissected by many small streams, which have cut deeply into the Waverly sandstones and shales, thus forming hills with steep bluffs and narrow ridges. The area east of the California Valley, although traversed by numerous small streams, is more varied, as the soft coal formation strata have yielded more readily to erosive forces, which have thus widened the valleys and rounded the hills. An exception to this is in Madison Township, where the streams in cutting through the massive Sharon conglomerate have left the hills steep and the valleys gorge-like.

DRAINAGE

Present Streams

The Ohio River receives directly or indirectly the waters from the entire region. The Scioto River, which enters the county from the north, flows south, and empties into the Ohio at Portsmouth. It receives the drainage of only a small territory east of the stream, which comprises Valley Township and the western parts of Clay and Jefferson townships. The Little Scioto River, which is formed by the junction of Brushy and Rocky forks, flows southward, and empties into the Ohio near Sciotoville. It is the most important stream in the eastern part of the county, and, as it lies in the basin of the old California Valley, it drains Harrison, Madison, and parts of Porter, Clay, Jefferson, Bloom, and Vernon townships. Pine Creek, which heads in Lawrence County, flows southward into Scioto County, and empties into the Ohio above Wheelersburg. It drains parts of Green, Vernon, and Bloom townships.

Old River Valleys

A system of preglacial rivers, which flowed northward across the county, and greatly modified the topography, can be traced by their old valleys, that now are of special interest on account of their history, and on account of the fertile farming lands found in them. These old rivers left large areas of level or gently rolling lands, which otherwise would have been broken and hilly; thus the valuable uplands of Dogwood Ridge, with the level belt extending northward past Harrisonville and Stockdale, are but the flood plain of the old Teays River. The effects of the old rivers are shown also by the meanderings and directions of the courses of some of the present streams; for example, the waters from the head of Long Run, which rises about three miles from the Scioto, and three and one-half miles from the Ohio, travel over 30 miles before they finally reach the latter stream. The tortuous course and gorge-like valley of the Little Scioto, from Harrison Mills north to the county line, is due to the stream having been formed from several tributaries of the old Teays River. The history of the main stream has been given by W. G. Tight, who made a careful study of the region. The two old rivers of importance recognized by him are the Teays and the Portsmouth.

California Valley.[1]—North of Wheelersburg and near Stockdale, in Scioto

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[1] Prof. Paper No. 13, United States Geological Survey. Drainage Modification in Southeastern Ohio and Adjacent Parts of West Virginia and Kentucky, by W. G. Tight, pages 57-58.

A.—Valley of the preglacial Teays River near Wheelersburg, Scioto County. This valley is about 150 feet above that of the Ohio River, and more than 1 mile wide.

B.—An old valley near Bloom Station in Scioto County cut at nearly right angles by Hales Creek. The main valley appears in the background.

County, and extending into Pike and Jackson counties, is the old California Valley, which has been described by the author and Mr. Frank Leverett, and correlated, with considerable confidence, with the Flatwoods and Teays valleys, on the basis of the grade of the old valley floor and the deposits found upon it, which consist of gravel beds of quartz pebbles overlain by silt deposits. The southern portion of this valley is very deeply cut by the Little Scioto River and its tributaries, but the northern portion, in the vicinity of California Flats, and the area extending thence northward to the Scioto at Waverly, are very perfectly preserved. Its features may easily be observed from the train on the Ohio Southern Railroad at Beaver. Between the Ohio at Wheelersburg and the Scioto at Waverly this floor has at present at least five water partings across it, which is suggestive of the great length of time which has elapsed since its abandonment and the establishment of the present drainage. The elevation of the valley floor where it is cut by the Scioto Valley is, as near as can be estimated, about 600 feet above tide. This would make a grade of about nine inches to the mile between St. Albans, W. Va., and this point, a distance of about 100 miles. As indicated in the articles referred to, the topographic features of the California Valley are quite identical with those of the Teays and Flatwoods valleys, and the history of the cycles through which this region has passed is almost exactly similar to that of the other valley.

The deposits on these old valley floors differ markedly from those on the floors of the present through-flowing streams, that is, the Ohio and Scioto rivers. In the preglacial valleys the deposits are characterized by the presence of thick beds of clays with interbedded sands and by the absence of notable amounts of gravel, the pebbles of which are composed of limestone or igneous minerals, while along the Ohio and Scioto rivers the deposits are marked by the thick beds of sands and gravels, and by the composition of the materials, some considerable part of which is from limestone and granitic rock. In general the deposits are of two distinct types, and they represent two periods in the history of the streams. Thin beds consisting, in the main, of sandstone bowlders and pebbles, flint from the Maxville, Pottsville, and Allegheny limestones, and quartz pebbles from the Sharon conglomerate, which outcrops in the adjacent hills, are usually found lying on or close to the bed-rock, while above this are present heavy beds of light gray or bluish clays, where unweathered, with interbedded sands, which in places are highly comminuted. These deposits represent the deposition work of the streams during their period of normal activity. Along the margins of the old valleys, and on the water divides of the streams now dissecting them, heavy beds of clays, highly stratified, and distinguished by their plastic, soapy character, and by their freedom from sand, compose the upper layers of the valley deposits. These clays were laid down in quiet waters during the slack-water or flood stage, which resulted from the damming of the lower courses of the streams by the advancing ice sheet.

Portsmouth Valley.[1]—Excepting the Teays River, the most important of these old streams thus mapped and described by Tight is the Portsmouth, which, flowing northward from the city of the same name, crossed into Pike County. The valley of this stream is now occupied by the Scioto River.

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[1] Prof. Paper No. 13, U. S. Geol. Surv., pp. 33-4.

Between Sciotoville and Portsmouth the valley is again constricted, and there is another col, which will be called the Portsmouth col. The valley is not so narrow at the Portsmouth col as at many other points where it has cut through old divides, but the bordering hills are very high, rising from 350 to 400 feet above the river, and presenting very steep faces and often vertical cliffs to the river front, so that, while the valley is not so narrow, the location of a col at this point seems certain.

At Portsmouth the river valley bends southwestward and increases considerably in width. To an observer in the Scioto Valley the valley of the Ohio below Portsmouth seems the natural and direct continuation of the Scioto, and to the observer in the valley of the Ohio below Portsmouth, looking up the river, the Scioto Valley seems the natural and direct continuation of the Ohio Valley, as the Scioto River Valley broadens as one passes up the Scioto, while the valley of the Ohio narrows rapidly upstream above Portsmouth.

These features at this point are very suggestive with reference to the direction of the old drainage lines, and indicate that the old valley was continuous between the Scioto and the portion of the Ohio below Portsmouth.

It is interesting to note that all the smaller tributaries of the Ohio further downstream in this section enter the valley in a direction opposite to the course of the river. At Quincy, at the mouth of Kinniconick Creek, the topographic features indicate that the continuation of the valley of the Kinniconick was normally up the present Ohio Valley, or northeastward; and below the mouth of the Kinniconick the Ohio Valley begins to narrow rapidly until it reaches another marked constriction, in the vicinity of Manchester, where it is evident, from the steep sides of the valley walls and the elevation of the table-land on each side, that the river has here crossed another col, which will be known as the Manchester col.

East of Lucasville, and also in the northern part of Valley Township, northeast of Clifford, fragments of what evidently represent parts of the old Portsmouth River Valley are distinctly noticeable, as these high plains contrast strangely with the rugged topography of the country eastward, where the hills rise about 400 feet above them, or with the flood plains of the Scioto about 150 feet below these high plains. The elevation above tide of the surface of these plains, where least disturbed by the dissecting streams, is about 680 feet, while that of the rock floor, as nearly as could be determined, is about 640 feet. These figures agree with those of the California Valley, and thus tend to establish its relationship to the preglacial drainage. A comparison of the deposits on the rock floor of these upland plains to those on the flood plains of the Scioto shows also that the materials forming them were not derived from a common source.

The deposits on the flood plains of the Scioto are made up of alternating beds of gravel, sand, and silts, the first often very thick and the particles well sorted. On examination the pebbles, in the main, are found to be granite or limestone. This material is of glacial origin, as the gravel trains are easily traced to the drift sheet farther north. The deposits in the upland valleys east of Lucasville and northeast of Clifford are different in character. The headwaters of the Portsmouth River, as defined by Tight, reached the Upper Silurian limestones in Adams County, Ohio, and Lewis County, Ky. The main basin was carved from Devonian and Carboniferous rocks, which consist principally of shales and fine-grained sandstones. Irregular deposits of Maxville limestone, Sharon conglomerate, Sciotoville clay, and thin coals are found on the high ridges along the eastern rim of the basin. Fluvial deposits derived from such rock would be clays and fine-grained sands principally. The rock floor of these old stream beds is formed of Cuyahoga shales and sandstones, and the deposits at present, as nearly as could be determined, are from 20 to 50 feet in thickness. The deposits, where examined, show the following general structure and composition: on the bedrock there is a layer only a few feet in thickness, which is made up of clay, sand, and gravel, with some bowlders, ore nodules, and cherty masses; the next layer, which constitutes the main body of the beds, consists of irregular interbedded sheets of variable thickness of clays and of fine-grained sands, with some pebbles and cherty material scattered promiscuously throughout the mass, while the upper layer is usually clay. The bowlders examined were sandstone, and their texture is about what would be expected from locally derived sandstones or freestones. No limestone bowlders were noticed, but they may be present, for, owing to a lack of exposures, the chances of observing the lower layer of these deposits are few. The ore nodules are evidently from local sources, as ferruginous concretions are abundant in the Cuyahoga and Logan shales. On the horizon of the contact of the Pennsylvanian and Mississippian rocks there is found a thin, rather persistent stratum, which is made up of brecciated cherty material from the Maxville limestone, quartz pebbles from the Sharon conglomerate, and iron ore, the latter acting as the bonding material. This stratum, occurring well towards the summits of the ridges east of the Scioto, is the source of the cherty material now found incorporated with the clay, sand, and gravel on these old valley floors.

The gravel deposits are made up principally of two kinds of pebbles; one derived from the local sandstones, and another less abundant, originally derived from igneous rock. The percentage, shape, and size of the quartz pebbles in the latter suggest strongly that this material was derived mainly from the Sharon conglomerate, which is present in local areas in the eastern part of the basin, and not from the drift sheet to the north.

The disintegration of shales and argillaceous sandstones produces sediments consisting of clays and fine-grained sands. Since this class of rock makes up the thick strata of the basin walls, fluvial deposits in the valleys, under normal conditions, would be, in the main, sediments of this type. The evidence thus tends to show that the sediments were derived from local material and laid down by the old preglacial stream. From the above it is thus seen that there is a marked difference between the deposits in these upland valleys and those along the Scioto. The latter bear distinctly the stamp of glacial influence, while the former do not.

From a consideration of basin areas the Portsmouth River was only about one-fifth the size of the present Scioto, which has obliterated most of the preglacial valley from Portsmouth to Waverly. The course of the old stream, judging from the few distinct remnants of the old valley, was somewhat tortuous, but well intrenched in the broken land. The valley of the Scioto River averages between 1½ and 2 miles in width, while that of the Portsmouth, as nearly as can be determined, was about 1 mile.

These old preglacial rivers, which flowed northward through the territory for a very long period, cut broad valleys, and reduced the contour of the adjacent hills to more gentle slopes, thus developing large tracts of level or moderately level lands which are quite fertile, and well suited for agricultural purposes. The area of this land in the California Valley alone amounts to more than 30 square miles, and that in its tributaries amounts to at least 20 square miles. The area of this land in the original Portsmouth Valley cannot be determined, for a large part of the Scioto Valley is the work of the present stream, but the area was evidently less than that in the California Valley, as the volume of water, owing to the more restricted basin, was much smaller. The fragments of the old valley seen east of Lucasville and northeast of Clifford have an area of about 10 square miles.

These old valleys are not only of value for their fine farming lands, but they afford natural outlets for roads and railroads. Most of the pikes of the county follow them closely.

Stratigraphy

All the surface rocks in this region are of sedimentary origin, having been deposited by the agency of water. They consist of sandstones, conglomerates, shales, limestones, coals, iron ores, and clays. The thickness of the Mississippian sandstones and shales, which varies from place to place, is usually about 800 feet, while that of the Pennsylvanian strata, measured from the bottom of the Sharon conglomerate, if present, to the Middle Kittanning coal, which just caps some of the highest knobs, is approximately 490 feet; hence the total thickness of Carboniferous rocks is between 1,200 and 1,300 feet. All the stratified rocks found in this region belong to the Mississippian and Pennsylvanian, except the gravels and silts deposited by the old preglacial rivers and those laid down by the present streams, which belong to the Quaternary. All the strata have a fairly uniform dip south of east. Figured from the Sciotoville clay deposits as a base, the dip east is 43 feet to the mile, that south 13.5 feet, and that south of east 44.5 feet.

The alluvium and gravel deposits of the Quaternary system are first described, as they have no direct relation to the rocks of the Mississippian and Pennsylvanian systems, which are then taken up in ascending order, beginning with the oldest.

General Relation of the Beds in Eastern Scioto County

System.	Series.	Formation.	Member.
Quaternary.	Recent.		Recent alluvium and gravel deposits.
	Pleistocene.		Glacial and old river deposits.
Pennsylvanian.		Allegheny.	Middle Kittanning, Sheridan, Hocking, or No. 6 coal.
			Middle Kittanning clay.
			Red Kidney ore.
			Oak Hill clay.
			Lost Seam coal.
			Lower Kittanning, Newcastle, or No. 5 coal.
			Lower Kittanning clay and shale.
			Ferriferous, Limestone, or Baird ore.
			Vanport, Ferriferous, Hanging Rock, or Gray limestone.
			Clarion, Limestone, or No. 4a coal.
			Clarion clay.
			Canary ore.
			Clarion, or Hecla sandstone.
			Brookville, or No. 4 coal.
		Pottsville.	Homewood sandstone.
			Kidney ore.
			Tionesta, or No. 3b coal.
			Upper Mercer, Franklin, or Big Red Block ore.
			Upper Mercer limestone.
			Sand Block ore.
			Upper Mercer, Webster Block, or No. 3a coal.
			Lower Mercer, or Little Red Block ore.
			Lower Mercer limestone.
			Boggs ore.
			Lower Mercer, or No. 3 coal.
			Vandusen coal.
			Lincoln ore, or Jackson Sand Block ore.
			Bear Run coal.
			Quakertown, Wellston, Jackson Hill, or No. 2 coal.
			Black Band ore.
			Guinea Fowl ore.
			Anthony coal.
			Sciotoville clay.
			Sharon iron ore.
			Sharon, Jackson Shaft, or No. 1 coal.
			Sharon conglomerate.
			Harrison ore.

General Relation of the Beds in Eastern Scioto County—Concluded.

System.	Series.	Formation.	Member.
Mississippian.		Maxville.	Maxville limestone.
		Logan.	Vinton sandstone. Allensville sandstone and conglomerate. Byer sandstone.
		Cuyahoga.	Portsmouth shales. Buena Vista sandstones. Henley shale.
		Sunbury.	
		Berea.	
		Bedford.	

QUATERNARY SYSTEM

RECENT RIVER DEPOSITS

Deposits of alluvium and gravel, which were laid down principally during inundation periods, and which vary greatly in thickness, are found on the flood plains of the present streams. Along the Ohio and the Scioto rivers these deposits consist generally of thick beds of gravel, overlaid by beds of sand and clay. The gravel is largely of glacial origin, as it contains much limestone and granitic materials, which have been transported from the glaciated regions by the glacial and present streams. It is hard to define the work done by the glacial and by the present streams, as the latter receive a large quantity of material from the same source as the former received their loads.

The gravel beds along the Ohio, and especially along the Scioto, furnish much material for concrete, ballast, and road work. For concrete work the gravel is usually graded by screening into sizes, which may then be proportioned to the quantity of each desired. The bulk of the gravel thus used at Portsmouth is taken from the Scioto beds. The Norfolk & Western Railway used large quantities of this gravel for ballast, and formerly the county roads in the Ohio and Scioto valleys were faced with it. At present limestone has largely replaced gravel for road work. Most of the sand used in this vicinity in concrete, cement, and lime mortars was formerly taken from the Ohio and Scioto beds, but at present it is taken mainly from the latter source, as the sand beds along the Scioto are more available, and the sands contain fewer coal particles, which are objectionable for cement facings and for the white-coat plaster. The Scioto Sand Company of Portsmouth, which regularly markets sand and gravel, states:

> We obtain our material from the Scioto River, some being taken directly from the bed of the stream, and some from a bar thrown up by the current. Our apparatus is an overhead cableway with clam-shell bucket operated by a three-drum friction engine. The material is dumped from the bucket into a hopper which feeds it to the revolving screens where it is sized and washed at the same time and thence conveyed by gravity to the storage bins. We have three grades of material: the mixed sand and gravel just as it comes from the river; the washed, screened sand; and the washed, screened gravel. We have been in operation for only a year and a half and estimate our sales for the year 1913 at about fifteen thousand yards. Our material has given good satisfaction for plastering, brick-laying, concrete, and all that class of construction work.

The deposits laid down on the flood plains of Pine Creek and the Little Scioto are largely the work of the present streams, while those found on the terraces and uplands are due mainly to the preglacial streams. The present streams do not head in the glaciated region, and they were not at any time directly connected with it; hence the gravel found along these streams contains but little granitic material, except some quartz pebbles found along the Little Scioto which are derived from the Sharon conglomerate. The gravel is composed mainly of soft sandstone, derived from the Carboniferous rocks, but, owing to lack of better material, it is used locally for concrete work and for road facing. The sands along these streams contain silty material, which restricts their efficiency for cement mortars, as the extremely fine silica or alumina from this material becomes a component of the cement which is thus thrown out of the proper silica-alumina-lime ratio. They are used only to supply the local needs.

The clays of recent origin found along Pine Creek, and along the Ohio, Scioto, and Little Scioto rivers, are valuable for ceramic purposes, but as yet they have been used to only a small extent. They are well fitted for the manufacture of drain tile, both common and face red brick, fire proofing, and roofing tile. Several small yards at Portsmouth formerly worked these clays for common brick, but they now use Cuyahoga shale.

The following brief description of the plant of the Joshua Oakes & Sons Company, located near Haverhill, was furnished by Oscar Oakes:

> The company was organized in 1877 and incorporated in 1896. The clays used are of alluvial origin and are obtained from the upper flood plain of the Ohio River. The deposit, about 12 feet in thickness, consists of light or unweathered clay, and of yellow or weathered clay. Both clays have much the same working properties. They have excellent plasticity and are quite free from deleterious materials, such as bowlders, iron concretions, or sand. The mining of the material is a simple matter, as all that is required is to remove the soil, then loosen the clay by explosives, or by the pick. The ware is manufactured as follows: The clays are first put through a crusher to break up the lumps, then they are formed into a plastic mud in a pug mill. The properly tem-

pered mud then goes to the tile machine which shapes it into the size of ware desired. No difficulty is encountered here, as the clay produces an excellent body which is quite free from laminations, or body checks, and sufficiently strong to withstand factory handling. The ware is dried both in steam driers and on open floors, the method followed depending somewhat on the weather conditions and on the size of the tile. When thoroughly dry the ware is set in the kiln which is of the rectangular down-draft type and is 14 by 34 feet in size. Coal is used for fuel. The total shrinkage of the ware is moderately low; hence a rather uniform ware is produced. The vitrification range is sufficiently long to give good economy in the quantity of standard ware produced. The clay goes to a good body which, when properly burned, has a deep cherry red color. All sizes of standard and special tile are made for the trade, while red brick are produced when ordered. The shipping facilities are the Norfolk & Western Railway, and the Ohio River.

PLEISTOCENE DEPOSITS

These deposits are the work of the preglacial streams, and of those formed by the shifting of the former during the Glacial Period. These old river deposits are well represented by the undisturbed gravel and alluvium in the California Valley on Dogwood Ridge, north of the village of Wheelersburg, and on the flat lands from Wheelers Mills to Stockdale, in Pike County. The deposits are made up of sand and clay with but little gravel and are often 40 or more feet thick. Clays make up the bulk of the beds.

The later deposits formed along the streams during glacial time are well defined by the terraces on the lower course of the Little Scioto River. Near the mouth of the river these deposits are principally fine-grained sands, but farther up the stream they are clays, with but little sand; hence it appears that the former were laid down in slowly moving currents, while the latter were deposited in still or slack waters, or under lake-like conditions that existed in this valley during Pleistocene time. In the Scioto Valley only remnants of these old deposits are found. The preglacial deposits are made up mainly of sands and clays, while those of glacial age are gravels and sands. The clays are by far the most important of these Pleistocene deposits, although they are used but little at the present time. These beds contain large amounts of clays, well fitted for the manufacture of the common grades of ware, such as drain tile, both common and face red brick, roofing tile, and fire proofing.

MISSISSIPPIAN SYSTEM

The strata that make up the hills just east of the Scioto River belong to the Mississippian system. As the rocks dip eastward these beds go under cover a few miles east of the Little Scioto. They disappear on the Ohio near Haverhill; on Pine Creek, near Powellsville; on Plum Fork near the Harrison-Bloom Township line; on Frederick Creek near the Baltimore & Ohio Southwestern Railroad; on Laurel Lick Run near Pinkerman; on Bear Run, in Section 4, Bloom Township; on Holland Fork, in Section 24, Hamilton Township, Jackson County;

on Meadow Run or Little Scioto near Mabee; on Bucklick Creek, in Section 16, Hamilton Township, and north of this near the Scioto-Jackson County line. The formations that make up this series of rocks are Bedford, Berea, Sunbury, Cuyahoga, Logan, and Maxville. From surface measurements and from drill records the total thickness of the six formations is between 600 and 800 feet. Just east of the Scioto River the estimated thickness varies from 700 to 800 feet, while in the eastern part of the county the measurements obtained from drill records place the thickness between 600 and 700 feet. The rocks of the Maxville formation are limestone, while those of the other formations are, in the main, siliceous shales and argillaceous sandstones. The Bedford, Berea, and Sunbury formations in southern Ohio have not been subdivided, but the Cuyahoga and Logan formations have been separated by Hyde into several members, which will be named later.[1]

BEDFORD FORMATION

In Scioto County, east of the Scioto River, the Bedford formation appears along the flood plain of this stream in the northern part of Valley Township. Owing to deep cover it is seldom exposed for observation, and is not available for economic uses. This formation consists of shales with thin and medium bedded sandstones which are widely spaced.

BEREA FORMATION

In that part of Scioto County discussed in this bulletin the Berea formation is above the waters of the Scioto River in Valley Township. The formation is made up of sandstones, which vary in thickness from 1 inch or less to as much as 5 or 6 feet, and of shales which are also quite variable in thickness and usually very siliceous in character. As a general thing the bulk of the deposit consists of sandstones, although this is not always the case. Along the outcrop these sandstones are light gray or slightly yellow in color, but under heavy cover they are light blue, owing to the presence of ferrous oxide pigments. In the main, these sandstones are composed of finely divided quartz, with clay and iron compounds for the cementing material.

The Berea sandstones are well exposed in the cut of the Norfolk & Western Railway near the pumping station at the village of Clifford. Most of the layers at this place are from 2 inches to 3 feet in thickness. The usual measurement, however, is from 6 inches to 2 feet. The layers are highly ripple marked, and are broken into blocks by joint planes. A few of the layers show concretionary structure and a marked variation in thickness. Most of these rocks are quite weather resistant, but a few of them have a tendency to shell when exposed to severe conditions. In this area the Berea sandstones have been used only for minor purposes, such as walks, foundations, culverts, and retaining walls.

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[1] J. E. Hyde, Stratigraphy of the Waverly Formation of Central and Southern Ohio, The Journal of Geology, Vol. XXIII, Nos. 7 and 8, October-November and November-December, 1915.

SUNBURY FORMATION

The Sunbury formation, which is composed of dark shales, is the next division of rocks in ascending order in the geological column. East of the Scioto River the beds are found above drainage from the vicinity of the village of Lucasville to the Scioto-Pike County line. Records of drill tests made in southern Ohio tend to show that the Sunbury shales and also the Berea sandstones are quite persistent. The usual thickness of the Sunbury formation is from 20 to 30 feet, although these measurements do not represent the extremes. These shales are characterized by their large content of carbonaceous matter. In this respect they bear a close resemblance to the shales of the Ohio formation of the Devonian system. Further, they are conspicuous on account of their dark, or coffee brown, color, and on account of their finely stratified structure. They are hard fissile shales, not easily attacked by weathering agencies, and they often contain many small concretions of pyrite. The Sunbury shales are not economically important at present, yet they may be utilized in the future as a source of valuable compounds produced by destructive distillation.

CUYAHOGA FORMATION

This formation has been subdivided by Hyde into three members, which are Henley, Buena Vista, and Portsmouth. Rocks belonging to this formation are found along the east bank of the Scioto River from the Ohio River northward to the Scioto-Pike County line. They extend well towards the headwaters of the eastern tributaries of the Scioto River, and appear along the courses of some of the western tributaries of the Little Scioto River. Along the Ohio River the formation passes below drainage near the mouth of the Little Scioto, just east of the village of Sciotoville.

The Henley member, which forms the lower part of the Cuyahoga formation, consists of siliceous shales, which as yet have not been used, but are well suited for ceramic purposes. The Buena Vista member lies above the Henley and is made up of sandstones and shales, which east of the Scioto River in this county have but little value. The Portsmouth member, which forms the upper part of the Cuyahoga, consists of shales that constitute one of the most valuable assets of Scioto County.

In a general way the Portsmouth member is represented along the courses of the streams in the area lying between the preglacial California Valley and the Scioto River. These deposits are very important along the Ohio River from Portsmouth to Sciotoville, where they form the basis of an important paving brick industry. The following section, taken at the mines of the Peebles Paving Brick Company, shows the general character of the deposit:

		Ft.	In.
Pottsville formation.			
Shales		15	--
Clay, flint, siliceous, *Sciotoville*		3	6
Shales and covered		10	--
Logan formation.			
Sandstone		55	--
Shales and sandstones		158	--
Cuyahoga formation.			
Shales, bluish, siliceous	*Portsmouth*	35	--
Sandstone, ferruginous		2	--
Shales, bluish, siliceous		90	--

The Portsmouth shales in this locality are fossiliferous, and afford good collecting. The fossils are usually found in ferruginous concretions.

ECONOMIC VALUE

The Portsmouth shales form the basis of the extensive paving brick industry in the vicinity of Portsmouth and Sciotoville. The quantity of suitable material in these beds is practically unlimited, as the shales have been attacked only at a few places along the outcrop. At present the mining is confined to blasting the shales from the sides of the hills, or to working the beds by short entries. Owing to the availability and thickness of the shales the cost of mining the material is low.

The working qualities of these shales are excellent. On exposure they weather down to mud with good plasticity. This property is also easily developed in the manufacture of the shale into brick by grinding it in dry pans, screening to remove the coarse material, and working with water in a pug mill. This process produces a good bonding of the mass. For paving brick, the column, as it is forced through the die of the brick machine by the auger, must not crack or laminate, as these are vital defects. In general, excess plasticity develops lamination, while insufficient plasticity produces crack. This shale gives a column not subject to either of these defects to any considerable extent. The brick show good structure throughout.

The brick are then pressed, loaded on cars, and taken to the drying tunnels. With many shales the direct loss of ware in the tunnels, due to cracks and checks, seriously impairs their value for ceramic purposes. Drying strains which develop during the burning of the ware as cracks, checks, warping, or dishing, are also often produced in the drying tunnels. Ware from this shale dries safely in almost any type of drier. From the drier the ware goes to the kilns, where it is set and burned. For paving brick certain general qualities are demanded by the trade. Brick, to withstand heavy hauling when laid in the streets, must be free from laminations, checks, and cracks. If these are present the brick are soon reduced to small pieces.

Shales with high drying and fire shrinkage are liable to warp and twist during burning. With this shale the total shrinkage is low; hence but little ware is lost through this defect. The shrinkage generally reported is one-half inch drying and one-half inch fire, or the total shrinkage is approximately one inch per foot. Vitrification develops the hardness, toughness, and low absorption required in this class of ware in which the finished product must be a dense, stony mass. The components to be considered here are of two kinds: those that tend to fuse to a glassy mass, and those that tend to remain rigid or resist solution. If the former predominate, the mass fuses to a brittle glass, with but little toughness or abrasive power. If the components producing rigidity are in excess, then the mass has an open, porous structure, unfitted to withstand the strains required. When the components are properly adjusted, a dense, stony, tough mass is produced, which resembles what is obtained from the natural Portsmouth shale. The vitrification range is another important item. This is the interval from incipient fusion to deformation. If this range is short the brick on the head of the kiln will be fused before those on the bottom of the kiln have started to vitrify, so ware will be lost either by overburning on the head or by underburning on the bottom.. The most active common components are magnesia and lime, which are both low in this shale. The burners at the present plants have no difficulty in obtaining good results from top to bottom of the kilns.

The colors usually demanded for first-class brick by the trade are from dark red to nearly black. The iron oxide in the shale is sufficiently high to give a dark red in a hard burn, under oxidizing conditions of firing, and a nearly black under reducing conditions during the latter part of the burn. The white or yellow scum on brick gives them an unsightly appearance, although it is not detrimental to this class of ware. The scum is produced either during drying in the tunnels or during the first stages of water-smoking in the kiln, but generally in the former. If the water in the green brick, which holds soluble salts in solution, is allowed to collect in beads or drops on the surface of the ware, and is then evaporated, the salts are deposited and remain as scum. Care in the drying and in the water-smoking of the ware will usually overcome this defect. The quantity of soluble salts in the Portsmouth shale is small, but scum is produced at times in the ordinary practice of manufacture. Formerly, glazed paving brick were demanded by the trade, but this grade at present is seldom required. The siliceous nature of the clay, and the high temperature of maturity, reported to be from 2,000 to 2,200° F., are both favorable for ease of salt glazing.

All points considered, the Portsmouth shale stands as one of the best in this state, or even in the United States, for the manufacture of high-grade paving brick. The deposit extends from the western boundary of the county to the Little Scioto River. The shipping facilities of the region are also good. The low freight rates on the Ohio River open the markets along this stream, and along the Mississippi. The two railroads, the Norfolk & Western and the Baltimore and Ohio Southwestern, afford means of shipping directly into the eastern, northern, and western markets.

This region is also favorably situated for fuel, as the Baltimore & Ohio Southwestern Railroad connects directly with the Wellston and Hocking coal fields, while the Norfolk & Western Railway enters the great southern West Virginia and southwestern Virginia fields. Gas from the West Virginia fields is also piped to this region, and is used by two firms as the main fuel supply. The firms manufacturing paving brick from the Portsmouth shale are as follows:

The Portsmouth Paving Brick Co , Portsmouth, Ohio.
The Peebles Paving Brick Co , Portsmouth, Ohio.
The Carlyle Paving Brick Co., Sciotoville, Ohio.
The Scioto Fire Brick Co., Sciotoville, Ohio.

W. K. Dupre, of the Portsmouth Paving Brick Company, describes that plant as follows:

The plant, located in the northern part of Portsmouth, commenced making brick in 1892. The material used is weathered and unweathered shale (Portsmouth) from the beds in the hill just north of Portsmouth. These are mined along the outcrop from surface workings, by quarrying. The power at the factory is furnished by two 80-H. P. boilers with one 150-H. P. engine. The brick manufacturing equipment proper is one Phillips & McLaren dry pan, one Freese pug mill, one American Clay Machinery Company brick machine, and one Bonnot repress. Waste heat is used in drying. The eight down-draft kilns have a total capacity of 840,000 brick. Coal is used exclusively in burning the ware. The capacity of the plant is 25,000 standard paving block per day. Tests on our ware rate it with the best made in the United States. The ware is marketed principally in Virginia, West Virginia, Ohio, Indiana, Kentucky, and Michigan.

A description of the Peebles Paving Brick Company reported by H. B. Murray, Jr., secretary and treasurer, is given below:

The plant of The Peebles Paving Brick Company is located about one mile east of the city of Portsmouth in Scioto County, and is bounded on the north by the rails of the Norfolk & Western Railway, and on the south by the Ohio River. The company was organized on Feb. 5th, 1902, for the purpose of manufacturing vitrified paving brick exclusively. The holdings of the company consist of two separate and distinct plants, each having a daily capacity of approximately 50,000 brick.

The shale from which the brick are made is dug from the face of the hills about one quarter of a mile distant from the plant by a Marion Model-60 steam shovel, and is hauled in dump cars by locomotives to the plant. The power plant consists of four horizontal tubular boilers, each rated at 125 H. P., which supply power for one Harris Corliss engine which at present is developing about 250 H. P., and one Excelsior slide-valve engine which is furnishing approximately 240 H. P. Each engine has its own plant to run, which consists of two 9-foot Bonnot dry pans, one 12-foot Bonnot pug mill, one "C" Special Bonnot brick machine, one E. M. Freese Model-T-60 reciprocating cutter, and on our No. 2 plant two Bonnot Canton-Special repressers. The product from this plant is repressed block and from the No. 1 plant it is the Dunn wire-cut lug block, which of course does not require pressing.

The brick are dried by the waste heat system which is supplied from cooling kilns by exhaust fans. The No. 2 plant has ten rectangular down-draft kilns each having a capacity of about 110,000, while the brick from the No. 1 plant are burned in the Haigh process continuous kiln which has 69 chambers each holding approximately 12,000 brick. Recent reports of tests which we have received from various cities using our block show them to average about 16 per cent under the Specifications for Testing Paving Brick as prescribed by the National Paving Brick Manufacturers' Association.

Our shipping facilities consist of Baltimore & Ohio Southwestern, and Norfolk & Western railroads, and the Ohio River. We ship annually several million brick by water to down-river points.

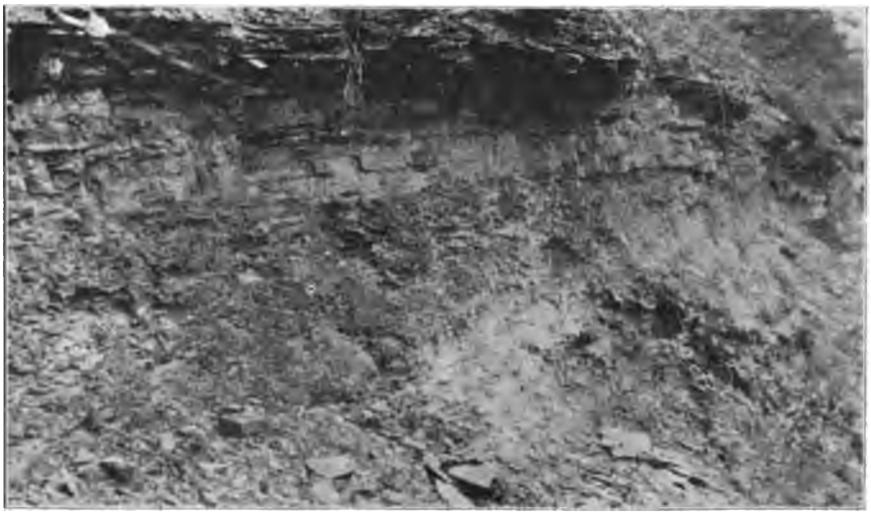
G. E. Carlyle, president and general manager of the Carlyle Paving Brick Company, reports as follows:

The Carlyle Paving Brick Company was organized May 2, 1905, and is an Ohio corporation. Our capital stock is $80,000, although we have invested double this amount since the plant was organized. Our plant is located one mile west of Sciotoville, Ohio, on the lines of the Norfolk & Western, and Baltimore & Ohio Southwestern railroads, Portsmouth electric line, and Ohio River. We have facilities for loading by rail and by river. The Ohio River has been of great assistance in disposing of our output. We have been able to ship by water to all southern points located on the Ohio and on the Mississippi rivers, and have thus disposed of from thirty to forty per cent of our output.

The production of our plant is one million brick per month. We are equipped with a 250-H. P. boiler and engine, one Champion crusher, two 9-foot Stevenson pans, piano-wire screens, Freese pug mill and brick machine, rotary cutter, two Eagle represses, and other necessary machines. The double-decked drier, possibly one of two of this type in the United States, consists of 12 tunnel tracks. It is equipped with two hydraulic elevators to raise and lower the wet and dry brick and is operated with waste heat drawn from our kilns by large fans. We have eight rectangular kilns, 18 feet wide and 86 feet 6 inches long, with a capacity of 115,000 brick per kiln. These are filled and drawn once every twenty-five to twenty-eight days and they have been very satisfactory. For fuel in burning we use coal that is shipped by way of Baltimore & Ohio Southwestern Railroad from Blackfork, Carbondale, and Canaanville. All of these coals have given us satisfactory results.

Our brick have been tested and used in the following cities: Chicago, Ill.; Dayton, Chillicothe, Columbus, Toledo, Cincinnati, Portsmouth, Ironton, Ohio; Huntington, Welch, W. Va.; Louisville, Covington, Newport, Bellview, Maysville, Ashland, Lexington, Winchester, Ky.; Memphis, Tenn.; Albany, Jeffersonville, Ind.; Norfolk, Roanoke, Suffolk, Va.; New Bern, N. C.; and Detroit, Kalamazoo, Mich. We have had numerous tests made of our ware and on several occasions offered to furnish a rattler so that each car load could be tested separately. We shipped 1,100,000 brick to New Bern, N. C., and furnished a rattler to test each car load if desired. We did the same last year at Winchester, Ky., where we furnished 500,000 brick. We are now shipping brick to Sidney, Ohio, under the same conditions, and our rattler is testing each car load or as often as the engineer cares. Our brick are usually sold under a guarantee of less than 18 per cent loss in the old standard rattler, and of less than 21 per cent loss in the new standard rattler. The city of Roanoke, Va., made a test in 1906 in which our brick lost 13.73 in the old test. Newport, Ky., made a test in 1908 in which

A.—Plant of the Peebles Paving Brick Company, located on the Ohio River east of Portsmouth. Photo by V. E. Fowler.



B.—Sciotoville clay with the overlying Anthony coal exposed in the cut of the Baltimore & Ohio Southwestern Railroad near Gephart, Scioto County. The Sharon conglomerate at this place lies just below the clay.

the average of two tests was 13.8. The city of Dayton, in 1908, made two tests in which the average was 13.68. In 1909, John Minwegan, Chairman of the Paving Committee of the city of Chicago, stated, "Carlyle paving brick shipped to Chicago are of the best quality in this country. Have highest and most severe rattler test. Will answer any further inquiries." In 1905, we furnished the city of Kalamazoo, Mich., with enough brick to lay a street, and we asked them what the condition of the brick was on May 20, 1911. Their reply was as follows: "Yours of recent date received. Would say that your brick are very satisfactory and that they stood up as well as any that we have used." In 1910, Mr. Wetherford, City Engineer of Memphis, Tenn., made two tests on the old standard rattler which gave him 11 per cent loss on one test and 13 per cent on the other.

In a general way we regard the shale used in the Portsmouth district equivalent to any material used in the United States for the manufacture of paving brick. With a reasonable amount of care the best tests, and the most durable pavements, can be secured and we believe the plants in the Portsmouth district can show more miles of good paving than any other one when the output is taken into consideration.

The Scioto Fire Brick Company operates a paving brick plant as a separate department to their fire brick works. The following report on the paving brick plant was kindly furnished by A. M. Turner, general manager and treasurer of the company:

The plant is located on the Ohio River at Sciotoville. The materials used are Portsmouth shale from the base of the hill just west of the plant, and plastic clay on the Sciotoville clay horizon from near the top of the hill. The materials are mined both by surface working, and by drifting. The power at the factory is furnished by a 100-H. P. boiler and engine. The dry pan, pug mill, presses, and tunnel drier have a capacity of 16,000 brick per day. The brick are dried in the tunnels by waste heat from the kilns, or by heat from steam coils with induced circulation by fans. The burning is done in seven rectangular down-draft kilns with a capacity of 40,000 brick each. The fuel used at present is natural gas, but the kilns are equipped also for coal. The annual capacity of the plant is 3,000,000 brick. The numerous tests on our brick rank them with the very best made in the United States.

Two firms manufacture both filler and line wire-cut building brick from the Portsmouth shale. They use a large per cent of the surface or weathered shale with the unweathered which gives a suitable working mixture. The burned ware has good structure and color. G. H. Heinisch, Portsmouth, Ohio, who uses this shale reports as follows:

The plant is situated on Gallia street in the east end of Portsmouth. It was built in 1910 by Heinisch and King, but is owned at present by G. H. Heinisch. The material used is Portsmouth shale, both weathered and unweathered. The plant is equipped with a 75-H. P. engine, 150-H. P. boiler, Stevenson dry pan, Freese pug mill, and brick machine. Exhaust steam is used in drying the ware, which is then burned in five up-draft kilns. The capacity of the plant is about 2,000,000 common building brick per year, most of which are used locally, but some are shipped by the Baltimore & Ohio Southwestern or Norfolk & Western railroads to points in Ohio, Kentucky, and West Virginia.

The other plant using this shale is the East End Brick Yard, operated by C. E. King. The yard is located at Gallia street and Mabert road, Portsmouth, and the material used is the blue and gray or weathered shales. The brick are manufactured by the stiff-mud process, with machinery made by the C. W. Raymond Company, Dayton, Ohio. The drying of the ware is done in 4 tunnels, using hot air for the expulsion of the moisture, while the burning is done in both up-draft and down-draft kilns. The daily capacity of the plant is 12,000 building brick.

This shale has not been used for sewer pipe, although its working and burning properties are well suited for the manufacture of this ware. The shale may be lacking somewhat in plasticity, but this can be supplied by mixing with it a small quantity of plastic clay or weathered shale from the Sciotoville clay horizon which is found on the main ridges above the shale deposits. The ware dries easily without checking, and it is sufficiently strong to withstand factory handling in the green state. It burns to a good dense body with low shrinkage, and takes a salt glaze readily. The proximity to the fuel supply, and to the shipping facilities are also favorable for success in this industry.

LOGAN FORMATION

The Logan formation in southern Ohio has been subdivided by Hyde into 3 members, which are Byer, Allensville, and Vinton. In the territory under discussion Logan rocks extend in a general way eastward from the Scioto River to a few miles east of the Little Scioto River. Along the Ohio River they are found well towards the summits of the main ridges at Portsmouth, but, owing to the dip of the strata south and east, they disappear below drainage near the eastern boundary of Green Township. The Logan formation is made up primarily of sandstones and shales, although in local areas it also contains thin beds of conglomerates, and iron ores. As a whole, the rocks of this formation are not especially important, yet some layers of the sandstones are used for minor purposes.

MAXVILLE LIMESTONE

The rocks of the Maxville limestone are the youngest in the Mississippian system and lie directly below the Sharon conglomerate of the Pennsylvanian system or below the base of the true coal formations. This formation is represented only by isolated patches or pockets of limestone. The Maxville beds were laid down on the floor of the Logan and were then cut away from the top, which action left only small isolated areas that stand out like islands in the ocean. The evidence tends to show an extended period of erosion at the close of Maxville time. Pebbles of Maxville limestone, altered to chert, are abundantly present in the basal beds of the Coal Measures, especially where the Maxville has been removed by pre-Pennsylvanian erosion.

The elevation and erosion after the Maxville deposits were laid down account undoubtedly for most of the disconformity noted at the top of the Logan, especially in the regions where the Maxville limestone is not present. As the Maxville deposits are small and widely scattered it is hard to study the base of the beds, but the similarity of the chemical analyses of the upper layers, when followed from Olive Hill, Ky., to Ironton, Ohio, and then to the McGugin and Harper deposits along the Lawrence-Scioto County line, with the change in elevation seen on Woods Ridge, and at other places, indicate either a basal disconformity or a variation in the thickness of the beds in different localities. The disconformity at the top of the Maxville has been shown by W. C. Morse in his report on the Maxville limestone.[1]

The Harrison ore, which commonly overlies the Maxville, and is there very intimately associated with it, is believed to be rather the basal member of the Pottsville, and is so treated. It is not improbable however, that the top of the Maxville limestone has been altered to an ore by iron-bearing solutions subsequent to the deposition of the Pottsville, in which case the ore bed is not a stratigraphic bed, but the altered top of the Maxville. This is referred to again in the description of the Harrison ore bed.

Stratigraphy and Extent

Clay Township.—Both the Maxville limestone and Harrison ore are found in local areas in Clay Township. From here the formation passes southward into Kentucky, where, on Tygert's Creek, and at other places the limestone has excellent volume and purity. In the vicinity of Olive Hill and Lawton Station the limestone is approximately 90 feet in thickness. North of Portsmouth, Ohio, in sections 3 and 4, Clay Township, 3 small areas of Maxville limestone are found near the summits of high knobs. These deposits are about on the level of the Sciotoville clay found one-half mile east. On the Jesse Weimer farm, near the head of Munn Run, in Section 26, is found a small pocket of limestone which is also represented by scattered nodules of flint and limestone on 2 high hills just southwest of his property. This nodular zone lies a few feet below a heavy sandstone, which about 1 mile north forms the roof of the Sciotoville clay. In Section 22, on the property of Ernest Cline, both the Sciotoville clay and Maxville limestone were seen on the outcrop. The thickness of the limestone, which is flinty in character, was not obtained. The interval reported by Mr. Cline from the clay to the limestone is from 8 to 12 feet.

Harrison Township.—Isolated patches of Maxville limestone were found only on Woods Ridge, in Harrison Township, but the brecciated flinty ore is far more widely distributed. In the northwest corner of Section 24 a few small areas of Maxville limestone are found near the summit of the ridge in the vicinity of deposits of Sciotoville clay.

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[1] Geol. Surv. of Ohio, Fourth Ser., Bull. 13.

Both deposits appear to be on the same level, but no section showing the relation of the two beds was obtained. Just east of this the Sciotoville clay is well developed, and it lies directly below a heavy sandstone, as is shown by the following section taken at the "Old Egypt" workings on the land of the Scioto Fire Brick Company:

	Ft.	In.
Sandstone	20	--
Coal blossom	--	1
Clay, flint, *Sciotoville*	4	--

In the eastern part of Section 24, on the Woods farm, the Maxville limestone is separated from this sandstone by an impure clay which may represent the Sciotoville member. The section follows:

	Ft.	In.
Sandstone	25	--
Green clay and covered	2	--
Ore, nodular	--	4
Limestone, *Maxville*, thickness reported	3	--

On the Henry Rider farm, in Section 20, one mile southeast of the Woods deposit, the intervals between the Sciotoville clay and Maxville limestone, and the Sciotoville clay and the heavy overlying sandstone, are greatly increased as shown by the section given below

	Ft.	In.
Pottsville formation.		
Sandstone, heavy, massive	30	--
Covered	20	--
Shales	20	--
Coal blossom.		
Clay, flint, *Sciotoville*	3	--
Shales and covered	23	--
Maxville limestone	1	6
Logan formation.		

Bloom Township.—Along the outcrop where the Maxville is due there was seen only the brecciated mass of Harrison ore and flint which was exposed at a few places on Frederick Creek, and on Laurel Lick Run. However, the Maxville formation is well developed on the Joseph Harper farm, in Section 32, Bloom Township, where it has been reached by the drill and a shaft. The drill record is as follows:[1]

	Ft.	In.
Surface	10	--
Sand rock	10	--
Black slate	1	--
Coal	--	4
Black slate	1	6
Grayish-blue slate	12	--
Sand rock	1	--
Fire clay	6	9
Black slate	1	6

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[1] Morse, W. C., Geol. Surv. of Ohio, Fourth Ser., Bull. 13, p. 90.

		Ft.	In.
Gray slate		1	6
Fire clay		2	--
Black slate		1	--
Gray slate		2	--
Black slate		1	6
Diamond (?) coal		1	--
Sand rock		1	--
Sand rock		8	--
Black slate		4	--
Sand rock		31	--
Blue sand rock		4	--
Black slate		16	--
Coal No. 2		1	--
Bed rock		6	--
Conglomerate rock		1	6
Bone shale		36	--
Green clay		1	6
Iron ore, *Harrison*		1	4
Limestone	*Maxville*	3	--
Green clay		1	--
Limestone		5	--
Dark sandy clay		3	6
Limestone		4	--
Clay		--	6
Limestone		15	--
Clay		--	8
Limestone		8	--
Clay		--	6
Dark limestone		1	--

Drill stopped.

All that remains of the original deposits of the Maxville limestone in Scioto County is thus a few scattered remnants of limestone. If the normal Maxville limestone had a thickness represented by that found at Ironton, where the strata measure 97 feet, then the period of erosion at the close of Mississippian time was of considerable duration. Further, at least a part of the erosion of the rocks in the upper part of the Logan formation, which has been noted under this heading, took place during this period. This disconformity is pronounced throughout most of the eastern part of the county.

Economic Value of Maxville Limestone

The Maxville limestone in Scioto County, except on the Joseph Harper farm, is thin, and the areas of the deposits small. It has but little value except locally for road making, although it was used in a small way for a flux by Harrison Furnace. In the Harper deposit there is at least 36 feet of good stone, but the area is unknown. A test, drilled on the Adam Brandt farm one-half mile north, failed to find the limestone, but south of this, near Olive Furnace, in Lawrence County, a record furnished by William McGugin shows 36 feet 9 inches of limestone. This deposit probably covers a considerable area, and in the future may be important. The quality of the limestone is shown by the following analysis of a sample from the upper part of the stratum in the Harper shaft. Analyst, Paul Overmeyer:

Iron, Fe	0.32
Silica, SiO_2	1.46
Phosphorus, P	0.014
Manganese, Mn	none.
Alumina, Al_2O_3	0.64
Lime, CaO	54.28
Magnesia, MgO	0.44
Sulphur, S	0.06

If all the lime and magnesia were combined as carbonates the results would be:

Calcium carbonate, $CaCO_3$	96.63
Magnesium carbonate, $MgCO_3$	.91
	97.54

The quality of the stone is shown by the above analysis to be very high-grade, and to be well suited for the manufacture of cement, for iron and steel furnace fluxes, for agricultural lime, and for other uses demanding a lime low in silica, clay, magnesium, sulphur, and phosphorus. The stone is dense, and makes good road ballast. The deposits are valuable and well worth thorough prospecting by people desiring high-grade material.

PENNSYLVANIAN SYSTEM

The Pennsylvanian system is divided into 4 formations, only 2 of which, Pottsville and Allegheny, appear in Scioto County. The full thickness of the Pottsville formation is present, but only the lower part of the Allegheny is represented. The Pottsville rocks extend from the Scioto River to the eastern boundary of the county, but the Allegheny rocks occur only in Bloom, Vernon, and Green townships.

POTTSVILLE FORMATION

The Pottsville formation embraces the rocks from the Maxville limestone to the Brookville coal of the Allegheny formation and consists of conglomerates, coals, clays, shales, thin limestones, sandstones, and iron ores. In a general way, these rocks just cap the highest knobs of the main ridges east of the Scioto River, and then, owing to the dip eastward, they gradually descend and pass below cover in Lawrence County east of the Lawrence-Scioto County line. When all the members are present the formation is about 400 feet thick, but, owing to the irregularities of the lower members, often it is represented by not more than 300 feet of strata. The Pottsville formation is subdivided into a number of members, which are shown in the general section, and which will be taken up in the order of their age, beginning with the oldest.

HARRISON ORE

There is commonly an ore bed immediately over the Maxville limestone which is usually so intimately associated with, and welded onto the limestone, that it might readily be interpreted as the top bed of the Maxville. Orton so regarded it, and called it the Maxville ore,[1] but Morse has shown that a similar ore in the Jonathan Creek region of Muskingum County is undoubtedly post Maxville, and almost surely basal Pennsylvanian.[2] In southern Ohio the apparent continuation of this ore bed is found not only over the isolated pockets of Maxville limestone but extensively at the base of the Coal Measures where the Maxville is missing by erosion, and its occurrence in every way indicates that it is the basal bed of the Pennsylvanian. The name Harrison ore is proposed for this member from Harrison Township, Scioto County.

Where the Maxville limestone is absent the Harrison ore is usually composed of a brecciated mass of flinty material derived from the Maxville, quartz pebbles and weathered sandstones, which are cemented by iron oxides and argillaceous components. In this form it is probably a sedimentary member, but it is not impossible that in some places this ore horizon is merely the iron-cemented basal conglomerate of the Sharon and not a true stratum. Where the ore rests on the Maxville limestone it is much more homogeneous, and the brecciated or conglomeratic character is absent. In this form it is commonly welded to the Maxville limestone in such a way as to suggest that it really belongs to and is a part of the Maxville. It is not impossible that the ore in some of these occurrences at least, is due to replacement or infiltration of the top of the limestone by iron from solutions circulating in the overlying porous sandstones and conglomerates, the iron derived from the higher iron-rich beds of the Pottsville. While this possibility must be kept in mind, Morse found that, even where the top of the Maxville limestone beds appeared to be altered in this way, the ore bed was equally developed where it rested on the shale beds of the Maxville and quite distinct from them. This indicates that the ore bed where it rests on limestone is a true sedimentary stratum belonging at the base of the Pennsylvanian.

The material of the Harrison ore, thus, varies greatly from place to place. From the evidence it is probable that it is a stratigraphic horizon throughout most of its extent, but it is possible that in places it is due to local alteration of previously existing beds, especially where it is at the top of the Maxville limestone.

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[1] Geol. Surv. Ohio, Vol. V, The Iron Ores of Ohio, pp. 373 and 379.

[2] Geol. Surv. Ohio, Fourth Ser., Bull. 13, p. 47.

Harrison Township.—The Harrison ore, which is somewhat fossiliferous, was found at the forks of the road, on Niner Ridge, in Section 20. The measurement of the strata along this road is as follows:

	Ft.	In.
Pottsville formation.		
Shales	12	--
Coal blossom.		
Clay, impure, *Sciotoville* horizon	3	--
Sandstones, thin-bedded	11	--
Coal blossom.		
Shales, parts covered	32	--
Ore, *Harrison*	2	--
Logan formation.		
Shales and sandstones	120	--

On Munn Hill, on the Scioto Fire Brick Company's property, in Section 32, is shown the following section:

	Ft.	In.
Pottsville formation.		
Shaly sandstone	20	--
Coal, bony, *Anthony*	--	6
Clay, flint, *Sciotoville*	3	6
Shales and parts covered	38	--
Conglomerate zone, flint, bowlders, shale, ferruginous clay, *Harrison* horizon	2	--
Logan formation.		

In Section 12, on the Samuel Monroe farm, near the Little Scioto River, an ore was formerly mined for use at Harrison Furnace. This ore is probably on the Harrison horizon, but as only small fragments were seen its position was not definitely determined. It may be Sharon ore, the position of which is above the Sharon coal. On the Harrison horizon a deposit of ore and cherty material, lying only a few feet below a heavy sandstone, was noticed on the high knobs of the main ridge just north of Long Run, and along the line of sections 5 and 6. Loose flinty material was also observed at other places on the ridge.

Madison Township.—The Maxville limestone was not found in Madison Township, but the ore is present in several localities. In the eastern part of the area, where the Sharon conglomerate is present this brecciated mass of flint and ore occurs directly below the base of the conglomerate, although it is not persistent by any means. The relation of the Harrison ore to other well recognized beds is shown in the following composite measurement, taken on the land of Samuel Shoemaker, in Section 26:

	Ft.	In.
Pottsville formation.		
Shales and covered	30	--
Clay, flint, *Sciotoville*, outcrop exposure	3	--
Shales and covered	24	--

Pottsville formation.	Ft.	In.
Shales	10	--
Shales and covered	9	--
Coal, *Sharon*	--	4
Clay, bluish, tough	2	--
Covered	6	--
Sandstone, light, fine-grained	7	--
Ore, *Harrison*	1	--
Logan formation.		

At this place the ore was formerly mined by stripping, for use at Harrison Furnace.

Jefferson Township.—In Jefferson Township the brecciated Harrison ore is well represented near the summits of the main ridges, and is often from 2 to 3 feet in thickness. It is found at the base of a thick sandstone, which is evidently the equivalent of the Sharon conglomerate. No sections were taken showing the relation of the ore to well known beds, for only the Sciotoville clay is present in the areas, and this is confined to a few small isolated patches. The Maxville limestone was not found.

Valley Township.—The Harrison ore deposits extend westward along the main ridges from Jefferson Township into Valley, and have much the same character. The Maxville limestone is wanting.

Porter Township.—In that part of Porter Township west of the Little Scioto River the Maxville limestone was not found, while the brecciated Harrison ore is present in only a few localities. In the part east of the above mentioned stream the ore was observed more frequently, but the limestone was not seen at any place. On the hill at the mouth of Sugar Run, on the farm of Joseph Jenkins, in Section 14, the following members were measured:

Pottsville formation.	Ft.	In.
Shale	3	--
Covered	3	--
Ore, soft, siliceous, *Sharon*, very fossiliferous	1	--
Covered	3	--
Shale	6	--
Ore, *Harrison*, with flint and pebbles	1	--
Logan formation.		

The Sharon ore in the above section is remarkably fossiliferous, while the Harrison ore contains only a few poorly preserved remains. In the bed of Lick Run, on the farm of John Sweinberger, the Harrison ore lies at the base of a thick sandstone, which is the equivalent of the Sharon conglomerate. This section is given on page 485.

Green Township.—The Maxville limestone has not been found. The Harrison ore here has much the same general character as it has in the townships considered, but at a few places it has exceptional thickness. A composite section taken along Pattons Run shows the relation of the ore to other important members. The record follows:

	Ft.	In.
Pottsville formation.		
Sandstone	7	--
Disconformity.		
Clay, flint, *Sciotoville*	2	--
Covered	10	--
Sandstone, irregular, *Sharon*	20	--
Ore, *Harrison*, brecciated mass of flint, ore, and clay	4	--
Logan formation.		

In this locality the brecciated material should hardly be called an ore, as it is only a conglomerate mass of flint, ore, and clay, in which the iron oxides constitute only a small part of the whole.

Value of Harrison Ore

Harrison Furnace used the Harrison ore to a limited extent. The deposits are uncertain, but often have good thickness, although the quality of the ore is generally poor, as it is siliceous or is admixed with cherty material. The ore is of no importance at present.

SHARON CONGLOMERATE

The deposits of Sharon conglomerate vary from a true conglomerate carrying large quantities of coarse pebbles to a medium-grained sandstone with but few, if any pebbles. In Scioto County it is best developed along the Little Scioto River from the Pike County line to Harrison Mills, and thence south to Section 1, Porter Township. It lies in a basin the main axis of which is nearly due north and south. Both the upper and lower surfaces are very irregular. The erosion at the end of Mississippian time was quite extensive, as the upper members of these rocks are cut away from the top, leaving isolated knobs and ridges, and in places deep channels, which may represent old river valleys. The irregularity of the lower surface of the conglomerate is caused by its being deposited on this uneven floor, and the greatest thickness of the bed is in these shallow channels. The irregularity of the upper surface of the conglomerate appears to be due largely to the action of the currents that deposited it, and not to that of later modifying agencies. However, certain features indicate that after deposition the bed in local areas became a land mass and was changed to a slight extent. The conglomeratic sandstone found above the Sharon coal, and the pebbles noted in the Guinea Fowl ore, appear to have been derived from this source. The bed in Scioto, Jackson, and Pike counties usually ends somewhat abruptly, which would not be the case if acted upon for any considerable length of time by the leveling agencies of erosion, as it should then thin gradually, and should finally fade out in the other deposits. A bed 30 or 40 feet thick may go out in less than 100 yards by thinning from the top, or from both the top and bottom. It thus appears to have been laid down by strong currents on the greatly eroded floor of the Mississippian rocks, and to have been but little disturbed by later agencies.

Clay Township.—The Sharon conglomerate was not found in good development in Clay Township, but thin irregular masses of sandstones, which evidently represent the member, occur at a few places. In most of the area the Sciotoville clay lies close to the Logan.

Porter Township.—In Porter Township, the Sharon conglomerate, although somewhat better defined than in Clay Township, lacks continuity and characteristic development. It is usually a sandstone containing but few, if any, pebbles, and the deposits, confined to local areas, often mere patches, are outliers from the main body of the conglomerate found in northern Scioto, western Jackson, and central Pike counties. A few sections will be given in order to show the relation of the Sharon conglomerate to other members. On Lick Run, on the farm of Joseph Sweinberger, in Section 20, the following strata were measured:

		Ft.	In.
Pottsville formation.			
Sandstone, massive, pebbly at base	*Sharon*	15	--
Shale, black, very irregular		1	--
Sandstone, very irregular		2	--
Disconformity.			
Ore, *Harrison*		--	4
Logan formation.			

Just north of this, in Riepenhoff Hollow, the Anthony coal and Guinea Fowl ore were found lying close to the underlying Sharon conglomerate, but the beds were not definitely fixed by measurements. The conglomerate, or rather the sandstone, phase of the member, is present at a few places along Pine Creek, in Porter and Green townships. The relation of the Sharon conglomerate to the Anthony coal is illustrated in the following record, taken on the farm of Caroline Gleim, in Section 22:

	Ft.	In.
Pottsville formation.		
Sandstone, blocky, ferruginous	4	--
Covered	22	--
Sandstone, blocky, thickens to 10 feet near by	4	--
Shale	7	--
Coal, *Anthony*, reported thickness	1	10
Clay, shale, and covered	20	--
Sandstone, massive, *Sharon*	25	--
Covered	20	--
Logan formation.		

Green Township.—The Sharon conglomerate in Green Township is represented only by scattered patches of sandstones, with occasional pockets of pebbles. The deposits are found in a few localities on Pine

Creek and along the Ohio Valley. A composite section, taken on lands of M. Eakins and H. Miller, on Patton's Run, shows the relation of the Sciotoville clay and Harrison ore to the Sharon conglomerate. The measurements obtained follow:

Pottsville formation.	Ft.	In.
Sandstone	7	--
Disconformity.		
Clay, flint, *Sciotoville*, outcrop exposure	2	--
Covered	10	--
Sandstone, *Sharon*, conglomerate equivalent	20	--
Ore, *Harrison*	4	--

A thin stratum of Sharon conglomerate was seen on the land of H. C. Feurt, on the top of the hill just south of Franklin Furnace. Here the bed lies only a short distance below the Sciotoville clay, as shown by the record given below:

Pottsville formation.	Ft.	In.
Shale, blue	3	6
Shale, black, with thin coal bands, *Anthony* coal horizon	1	6
Clay, siliceous, *Sciotoville*	4	--
Sandstone, coarse-grained, *Sharon*	5	--
Logan formation.		

The horizon of the Sharon conglomerate passes below the flood plain of the Ohio River, north of the village of Haverhill. This member is below drainage in Vernon Township.

Harrison Township.—In Harrison Township, west of the old California Valley, only small scattered pockets of Sharon conglomerate are found, but east of this valley, especially along the Little Scioto River, many massive cliffs of this rock are exposed. Some of the best exposures are on Plum Fork, in Section 36, at the mouth of Frederick Creek, in Section 13, and near Wallace Mills, in Section 1.

The rocks exposed in the cut of the Baltimore & Ohio Southwestern Railroad, in Section 36, show the Sciotoville clay lying directly on the Sharon conglomerate, which is massively developed. The section follows:

		Ft.	In.
Shales, blue		27	--
Coal, dense	*Anthony*	--	4
Shale		--	2
Coal, dense		--	7
Clay, flint, *Sciotoville*, lower part siliceous, with quartz pebbles irregularly distributed through it		5	6
Conglomerate, *Sharon*, parts very pebbly		20	--

Bloom Township.—The Sharon conglomerate is found above drainage only in the western part of Bloom Township. The bed is well developed along Frederick Creek, in sections 17 and 18, and along the Little Scioto River, especially in parts of Section 6.

Madison Township.—The thickest deposits of Sharon conglomerate in Scioto County are found in Madison Township. Although wanting in some localities, the member is quite persistent in most of the area, but variable in thickness and in composition. A few sections will be given in order to show its thickness and to show its relation to other members. On the property of John Alexander, in the western part of Section 15, the rocks measured are as follows:

	Ft.	In.
Pottsville formation.		
Shale, lower part dark, fossiliferous	12	--
Coal, *Sharon*	2	2
Sandstone, *Sharon*, conglomerate equivalent	30	--
Logan formation.		

In Section 13, on land of Oliver Powell, the following strata were exposed:

	Ft.	In.
Pottsville formation.		
Covered	5	--
Ore, *Guinea Fowl*	--	6
Covered	6	6
Coal, *Anthony*, reported thickness	1	6
Shales and covered	47	--
Sandstone and conglomerate, *Sharon*	53	--
Logan formation.		

The rocks measured on the land of Jasper Culp, Section 12, bear the following relations:

	Ft.	In.
Clay and covered, *Sciotoville*, clay exposed, fine quality flint	5	--
Shale and covered	37	--
Coal, *Sharon*, seen on this level across hollow.		
Conglomerate, *Sharon*, upper part sandy, lower part pebbly	64	--

South of White Gravel Church, in Section 11, on the land of Francis Warren, the recorded section shows about the normal relation of the lower members of the Pottsville formation:

	Ft.	In.
Pottsville formation.		
Top of hill.		
Covered	60	--
Coal, *Anthony*	1	3
Clay, dark, plastic, *Sciotoville*, flint clay seen on same horizon just west	3	--
Covered	16	--
Shale	2	--
Ore, *Sharon*, good quality	--	10
Covered	8	--
Sandstone	2	--
Coal blossom, *Sharon*, thickness reported for coal and partings	3	--
Covered	5	--
Conglomerate, *Sharon*, pebbly	65	--
Logan formation.		
Covered	5	--

	Ft.	In.
Logan formation.		
Shale	2	--
Conglomerate of *Allensville*	1	--

On the hill east of Sugarcamp Creek, in Section 7, on the property of William Flack, the section taken is given below:

	Ft.	In.
Flint clay and covered, *Sciotoville*	5	--
Covered	45	--
Conglomerate, *Sharon*	35	--

The rock exposed in the road south of Dry Run, in Section 2, measured as follows:

	Ft.	In.
Pottsville formation.		
Shales and covered	75	--
Conglomerate, *Sharon*, very pebbly	30	--
Logan formation.		
Shales and sandstones	35	--
Conglomerate of *Allensville*	5	--
Shales and sandstones	45	--

Valley and Jefferson Townships.—Excepting a few thin deposits of coarse-grained sandstone which represent the member, the Sharon conglomerate is wanting in Valley and Jefferson townships. The rocks of the Logan formation lie close to the horizon of the Sciotoville clay of the Pottsville formation.

Economic Value

The Sharon conglomerate, when composed largely of pebbles, makes a good material for roads where the traffic is not heavy. It takes some time to pack, but when this is accomplished it produces a solid bed that lasts for several years. It has been extensively used in Madison Township for this purpose, and is reported to be very satisfactory. Along Millstone Run, where best represented, the deposit which varies in thickness from 20 to 70 feet is composed of loosely cemented sand and gravel. The pebbles having sizes from one to one-eighth inch make up from 30 to 70 per cent of the mass. The gravel is mainly quartz pebbles, which, if crushed, washed, and sized, would produce good abrasive material for sand-blasts and similar uses. The cost of mining and preparing limits somewhat its use for concrete and for other common purposes.

SHARON, JACKSON SHAFT, OR No COAL

The Sharon is the lowest coal bed of any importance in this State. Since its position is just above the Sharon conglomerate this stratum was appropriately designated Sharon coal by the geologists of Pennsylvania. When both conglomerate and coal are present, the interval separating the two beds is at most only a few feet, while in some places no intervening space exists, as the coal lies directly on the conglomerate rocks. The Sharon coal is represented only at a few places in Scioto

County, although the horizon of the bed extends from the Scioto River to a few miles east of the Little Scioto River, and east of the Ohio from Wheelersburg to Haverhill. In this area the member is above drainage in all the townships except Vernon. A number of measurements of the rocks will be given in order to show the relation of the Sharon coal to other important members, and to show its areal extent.

Clay Township.—Although the Sciotoville clay, the position of which is above the Sharon coal, is present at a number of places along the main ridges in Clay Township, the coal bed was not observed. Here the clay stratum lies very close to the Maxville or Logan rocks; hence the conditions appear to show that the Sharon coal was not deposited, or, if the bed were laid down, that it was eroded before the deposition of later coal formation rocks.

Porter Township.—The Sharon coal is poorly represented in Porter Township. Thin beds of dark carbonaceous shales, which appear to mark the horizon, are present at a few places on Lick Run and on Pine Creek. Deposits of good coal were not found in this township.

Green Township.—No coal of value was noted on the Sharon coal horizon in Green Township, although black shales with thin coal bands, lying only a short distance below the Sciotoville clay, are present in a few localities. The usual relation observed is shown in the following section, taken on the land of Conrad Gerlach, which is located one and one-half miles north of Franklin Furnace:

		Ft.	In.
Shale		2	6
Ore, nodular	*Guinea Fowl*	--	3
Clay		--	1
Ore, nodular		--	2
Ore, nodular		--	6
Shale		14	--
Covered		3	--
Sandstone		1	8
Shale, sandy		1	--
Coal, *Anthony*		--	4
Clay, flinty, siliceous, *Sciotoville*		2	--
Covered		6	--
Sandstone		1	--
Covered		1	--
Coal blossom, *Sharon*		1	--
Clay shale		2	--

Harrison Township.—Thin impure deposits of coal and carbonaceous shale on the Sharon coal horizon were noted in several localities in Harrison Township east of the preglacial California Valley, but the member is scarcely represented in that part of the township west of this old waterway. This bony coal lies on the Sharon conglomerate, which, locally, is massively developed in this eastern area. The deposits here have no economic value.

Bloom Township.—In Bloom Township the horizon of the Sharon coal is above drainage along Frederick Creek to the Baltimore & Ohio Southwestern Railroad, along Bearwallow Hollow in the western part of Section 7, along Laurel Lick Run to near the village of Pinkerman and along Bear Run to the central part of Section 4. The member is poorly developed, but is of interest on account of its relation to the Sciotoville clay, which has excellent volume and continuity in western Bloom Township. A record taken on the land of William Tripp, in the southwestern part of Section 7, shows the relation of the Sharon coal to other important members higher in the geological column, and is given below:

	Ft.	In.
Sandstone, massive	10	--
Coal, *Quakertown*, reported thickness	1	4
Shale and covered	35	--
Clay, flint, *Sciotoville*	3	--
Sandstone and shale, with parts covered	32	--
Coal, *Sharon*, reported thickness	1	8
Sandstone, with pebbles, *Sharon* conglomerate	4	--

In Bearwallow Hollow, Section 7, the Sharon coal was mined at one time for house use, and is reported to be about 2 feet in thickness. Near the Baptist Church, in Section 5, the horizon of the member is marked by black shales, the position of which is shown in the following section:

	Ft.	In.
Flint clay, *Sciotoville*.		
Covered	15	6
Shale, gray	10	--
Clay shale, black, plastic	5	6
Shale, gray, sandy	14	--
Ore, kidney, *Sharon*	--	6
Shale, gray, somewhat fissile	1	--
Clay shale, black, plant marked, *Sharon* coal horizon	1	6
Shale, gray, soft	10	6
Sandstone, shaly } *Sharon*	3	--
Sandstone, with pebbles	3	--
Covered	10	--
Sandstone, *Vinton*	4	--

Madison Township.—In Madison Township there are scattered patches of Sharon coal which have sufficient thickness for drift mining in a small way. The stratum lies close to the underlying Sharon conglomerate where this is present. A few sections will be given in order to trace the extension of the member northward to the important field of this coal in Jackson County. In Section 26, on the farm of Samuel Shoemaker, the Sharon coal has been prospected to determine its value. The bed consists of a thin layer of coal with carbonaceous shales. Sciotoville flint clay of excellent quality is exposed on the hill above the coal bed, while the Harrison ore was formerly mined below the coal. The record obtained at this place follows:

	Ft.	In.
Clay, flint, *Sciotoville*	3	--
Shales and covered	24	--

	Ft.	In.
Shales	10	--
Shales and covered	9	--
Coal, *Sharon*	--	4
Clay, bluish, tough	2	--
Covered	6	--
Sandstone, light, fine-grained	7	--
Ore, *Harrison*	1	--

The Sharon coal has been prospected along the outcrop at other places in this locality. West of the Salem School the blossom of the member, with associated black shale and siliceous clay, was exposed in the road near the home of J. J. Bonzo. This coal has been mined by drifting on the Ace May property, near Wallace Mills, in Section 36. The deposit is reported to be made up of a layer of good coal 1 foot in thickness, underlaid with a layer of cannel coal of about the same thickness. The blossom of the Sharon coal with an ore above was seen at two places in Section 24. West of this, in Section 23, on the property of William Kronk, the Sciotoville clay, with the Sharon coal only a few feet below, was exposed. The section taken at this place follows:

		Ft.	In.
Clay, flint, excellent quality	*Sciotoville*	2	2
Clay, plastic, dark and mottled		5	8
Shale, dark		3	--
Coal blossom, *Sharon*		2	6
Clay, dark, plastic		1	--
Covered		7	6
Sandstones, with shaly layers, *Vinton*		24	--

Near the Mount Carmel School, in Section 15, on land of E. Z. Allison, the coal has been mined by stripping, and is reported to be 1 foot 8 inches in thickness. In the same section, on the farm of John Alexander, this coal has been mined for local needs by drifting, and is reported to be from 2 feet to 2 feet 2 inches thick. In the northern part of Section 15, near the head of Higgins Run, a small area of Sharon coal is present, which has been mined by drifting for a number of years. The following section was taken on land of Harvey Odle:

		Ft.	In.
Sandstone, shaly		1	2
Coal, bony	*Sharon*	--	6
Coal, good		2	2
Clay		2	--
Sandstone, *Sharon*		6	--
Sandstone, *Vinton*		10	--

The coal at this place varies in thickness from 1 foot 11 inches to 2 feet 2 inches, and the clay below varies from a few inches to 2 feet. The bed has also been mined on the land of Wayne Hickman, in Section 16, and is 1 foot 8 inches in thickness. South of White Gravel Church, in Section 11, on the farm of Francis Warren, both the Anthony and Sharon coals are present. The section obtained follows:

	Ft.	In.
Coal, *Anthony*	1	3
Clay, dark, plastic, *Sciotoville*, flint clay seen on same horizon on next hill	3	--
Covered	16	--
Shale	2	--
Ore, kidney, *Sharon*, good quality	--	10
Covered	8	--
Sandstone	2	--
Coal blossom, *Sharon*, reported thickness for coal and partings	3	--
Covered	5	--
Conglomerate, *Sharon*	65	--
Covered	5	--
Shale	2	--
Conglomerate of *Allensville*	1	--

The blossom of the Sharon coal was exposed in Section 12, on land of Jasper Culp. The following section shows the interval to the Sciotoville clay:

	Ft.	In.
Clay, flint, *Sciotoville*, on outcrop	5	--
Shale and covered	37	--
Coal blossom, *Sharon*, seen across hollow.		
Conglomerate, *Sharon*, upper part sandy, lower part pebbly	64	--

On the ridge north of Dry Run, in Section 2, the blossom of the Sharon coal lying close to the conglomerate was noted at a few places. In Madison Township the Sharon coal is quite persistent in the area in which the Sharon conglomerate is present, but it seldom thickens to over a few inches, except in a few localities. It is usually marked by black bony shales with thin coal bands.

Jefferson Township.—The Sharon coal is wanting in Jefferson Township, except in a few localities where it is represented by a few inches of coal with black shales or clays. A section taken on the land of Joseph R. Keller, in Section 22, follows:

	Ft.	In.
Coal blossom, *Anthony*	--	6
Clay and clay shale	9	6
Clay, flint, *Sciotoville*	1	3
Sandstone, shaly, ferruginous	--	6
Sandstone, light, clay-bond	1	3
Sandstone	1	--
Shales, sandy	7	--
Sandstone, shaly, light	20	--
Sandstone, massive	13	--
Covered	8	--
Coal blossom, and dark clay, *Sharon* coal horizon	4	--
Covered	30	--
Shales and sandstones, *Vinton*	20	--

Only a few hills in Valley Township are of sufficient height to have Pottsville rock. The Sharon coal was not found.

Economic Value

The area of Sharon coal in Scioto County, exceeding 18 inches in thickness, is confined to a few square miles. In Madison Township a small quantity is mined for local use. The bed is uncertain in thickness and composition as it may pinch out in a short distance, or be replaced by carbonaceous shales and clays. In sections 15 and 16, Madison Township, where the member is best developed, the coal is reported to be of very good quality for domestic use. It is hard, bright, and quite free from shale bands or sulphur nodules. The mining of the coal is both difficult and costly, as the coal lying close to the uneven surface of the Sharon conglomerate is subject to dips and rolls. The value of the Sharon coal in Scioto County at present is small.

SHARON ORE

A kidney ore, the position of which is above that of the Sharon coal, and below that of the Sciotoville clay, was observed at a few places in Scioto County. Usually the ore lies on the coal, or within 15 feet of it. This member was found also in Jackson County, where the deposit has been mined in a few localities. The Sharon ore is generally wanting, but, when present, may have a thickness of 10 inches or more. Three exposures of the ore were noticed along the roadside in Section 24, Madison Township. Its position was just above the thin blossom of the Sharon coal, and the stratum measured 6 inches in thickness. A composite section on the land of George Winters, Section 22, is as follows:

	Ft.	In.
Clay, plastic, lower part "pink eye," *Sciotoville*	2	--
Covered	12	--
Ore	--	10
Shale, blue	2	--
Shale, dark, tough	1	--
Sandstone, *Vinton.*		

The ore has been mined on lands of George Winters, Samuel Kronk, and James Coburn, and is reported to be from 6 to 10 inches in thickness. On the Francis Warren property, in Section 11, the relation of the ore to the Sharon coal and to the Sciotoville clay is shown by the record given below:

	Ft.	In.
Coal, *Anthony*	1	3
Clay, dark, plastic, *Sciotoville*	3	--
Covered	16	--
Shale	2	--
Ore, *Sharon*	--	10
Covered	8	--
Sandstone	2	--
Coal blossom, *Sharon*, reported thickness of coal and partings	3	--
Covered	5	--
Conglomerate, *Sharon*	65	--

	Ft.	In.
Covered	5	--
Shale	2	--
Conglomerate of *Allensville*	1	--

On the farm of Joseph Jenkins, at the mouth of Sugar Creek, Section 14, Porter Township, the Sharon ore is well developed, and is very fossiliferous. The ore affords good collecting, as the fossils are well preserved and easily obtained. The measurements taken at this place follow:

	Ft.	In.
Ore, *Guinea Fowl*	--	6
Shale	3	--
Covered	3	--
Ore, soft, siliceous, *Sharon*, very fossiliferous	1	--
Covered	3	--
Shale	6	--
Ore, with flint and pebbles, *Harrison*	1	--
Sandstone, *Vinton*	22	--

The Sharon ore was noted at other places in this locality, and it also appears, but in a less developed state, in restricted areas along the Pine Creek Valley. The chief value of the Sharon ore in Scioto County is for stratigraphic work, as it is an aid in correlating the members near the base of the Pottsville formation. The fossils found in it are of special interest, as they show the character of the marine life that flourished at the beginning of coal formation time. Otherwise, the ore has but little value, as it is too siliceous to be used to advantage, at present, for metallurgical purposes. The Sharon ore was mined at a few places, however, for use in the old charcoal furnaces. Under deep cover the ore is of the usual carbonate or coal formation type, but along the outcrop, owing to the influence of weathering agencies, it belongs to the limonite class. It is usually somewhat siliceous in character, and, judging from appearance, has a low content of iron. At present the Sharon ore is of interest mainly for its paleontologic and stratigraphic features.

Stratigraphic Position of the Sciotoville Clay with Reference to the Sharon, Anthony, and Quakertown Coals, and to Other Members

The Sciotoville clay, which is one of the most important coal formation rocks in Scioto County, and which has been the basis of the important fire brick industry in this locality since 1864, has excellent volume and high purity in Clay, Porter, Harrison, Bloom, and Madison townships, and is found also, but to a more limited extent, in Green, Vernon, and Jefferson. As the member passes northward into Jackson, Pike, and Vinton counties it becomes patchy and more impure. However, in its extension southward into Kentucky the clay again has good continuity and volume, especially in what is known as the Olive Hill field, where it is also the basis of extensive fire brick operations. As the stratigraphic positions of the Sharon coal, Sciotoville clay, Anthony coal, and Quakertown coal have been somewhat confused, these members will be traced hurriedly from the Ohio River, in Scioto County, to the eastern part of Pike County and to the central part of Jackson County, where the Sharon and the Quakertown coals have good volume and excellent quality, and where the Anthony coal was first described by Prof. E. B. Andrews.

As the Sciotoville bed is variable both in composition and in structure, a brief description of the deposit will be given in order that the following pages may be more readily understood. On the Sciotoville horizon there is found a variety of clays which are called flint, semi-flint, plastic, and "pink eye." The flint clay is hard, homogeneous, non-plastic, and breaks with a conchoidal fracture. The semi-flint clay has much the same characteristics as the flint clay, except that it is somewhat plastic, and is marked with slicken-sides. As the name suggests the chief property of the plastic clay is plasticity. The "pink eye" clay is only a plastic clay which is colored with iron oxide pigments. These clays may be bedded in almost any order, although when all the varieties are present the usual arrangement in ascending order is "pink eye," semi-flint, flint, and plastic. However, the four kinds are seldom present at one place, but almost any combination of the four may be expected.

Where the Sciotoville member is made up of a number of beds or layers of clays, often there may be several coal strata on the horizon, any one of which may thicken locally. Thus a coal stratum found in one locality may not be exactly on the same stratigraphic level as another found not far distant, but both were laid down during a period when the general depositive conditions were the same; hence they are considered correlative. The term Anthony coal in this bulletin is applied to the best developed bed associated with the Sciotoville clay. It may rest on the flint clay when no plastic clay is present, but on or in the plastic clay when this is found.

SCIOTO COUNTY

As the Sciotoville clay has excellent continuity and development in large areas in Scioto County, especially in the region north of the town of Portsmouth, and along the valley of the Little Scioto River, this county affords a good place from which to trace the stratigraphy of the Sciotoville clay, and that of other members in the lower part of the Pottsville formation. However, in this area the Sharon and Quakertown coals are poorly defined, but the Anthony coal, in some state of development, is, with few exceptions, present with the Sciotoville clay. From Scioto County the members will be traced northward into Pike County and into Jackson.

Green Township.—In Green Township only a few isolated patches of Sciotoville clay were found, while the Sharon, Anthony, and Quakertown coals are scarcely represented. Where present in this township the Sciotoville clay lies very close to the Sharon conglomerate, or to the Logan rocks when the conglomerate is absent. On the lands of H. C. Feurt and A. J. Hyland, one-half mile southeast of Franklin Furnace, there is present a small area of flint clay, which is the most southern deposit found in Scioto County. The Anthony coal, the Guinea Fowl ore, and what appears to represent the Quakertown coal, are present above the clay. The following record shows the relations of the members exposed for measurement:

		Ft.	In.
Coal blossom, *Quakertown*		--	4
Clay, siliceous		2	--
Shale		13	--
Ore, *Guinea Fowl*		--	4
Shale		5	--
Coal blossom, *Anthony*		--	2
Clay, plastic, light	*Sciotoville*	1	4
Clay, flint, pure		1	--
Clay, flint, siliceous		2	6
Sandstone, clay-bond		1	6

Near the head of Pattons Run, on the lands of M. Eakins and H. Miller, another pocket of high-grade flint clay occurs. It lies close to a heavy sandstone which is the equivalent of the Sharon conglomerate. A composite section obtained at this place shows the relations of the members exposed, and is as follows:

	Ft.	In.
Sandstone	7	--
Disconformity.		
Clay, flint, *Sciotoville*	2	--
Covered	10	--
Sandstone, irregular, *Sharon*	20	--
Ore, *Harrison*, brecciated mass of flint and ore	4	--
Shale, *Vinton*	6	--

Porter Township.—No high-grade clay belonging to the Sciotoville member was found on Pine Creek or on Lick Run, but the Anthony coal, although usually thin and impure, is present at a number of places. On the farm of Joseph Miller, in Section 12, the Anthony coal, with siliceous Sciotoville clay below it, lies close to the Sharon conglomerate which here is represented by a coarse-grained sandstone. The measurements secured follow:

	Ft.	In.
Shale	8	--
Ore, *Guinea Fowl*	--	10
Shale	17	--
Coal, *Anthony*	--	7
Clay, siliceous, *Sciotoville*	1	6
Sandstone, *Sharon*, conglomerate equivalent	7	--

In Section 1, on the Elizabeth Hurst property, the Anthony coal, found lying just above the Sciotoville clay, has been mined for house

use, and is reported by Willard Hurst to be 1 foot 2 inches in thickness. The record taken near the Webster pike is as follows:

	Ft.	In.
Shale	30	--
Coal, *Anthony*, reported thickness	1	2
Clay, siliceous, *Sciotoville*	2	6
Sandstone, light, fine-grained, *Sharon*	2	--

Just north of the above section the Sharon conglomerate is thick and pebbly. In the western part of Porter Township the Sciotoville clay lies very close to the Logan rocks. In most of the area the Sharon conglomerate is wanting, and the conditions are much the same as they are in Clay Township.

In Section 12, west, overlooking the Ohio River, the following measurements, which show the thickness of the Anthony coal and of the Sciotoville clay, and which show further the short interval separating the clay from the Logan rocks below, were obtained at a mine near the summit of the hill:

	Ft.	In.
Shale	20	--
Coal blossom, *Anthony*	--	1
Clay, flint, lower part sandy, *Sciotoville*	14	--
Covered	12	--
Sandstone, *Logan*	50	--

The thickness of the Sciotoville clay in this section is above normal, and the quality inferior to that found in the hills to the north. In Section 36, Porter Township, the relation is shown by the following section:

	Ft.	In.
Shale	10	--
Coal, *Anthony*	--	5
Clay, flint, good, thickness seen	3	--

In this locality the coal above the clay is reported in places to be 10 inches in thickness.

Clay Township.—From Woods Ridge southward to the Ohio River near Portsmouth, in Clay Township, the deposits of Maxville limestone and Sciotoville clay are in places apparently on the same horizon, or are separated by an interval of only a few feet, the clay lying above the limestone. This is much the same condition as is found at Olive Hill, Ky., where the limestone is approximately 90 feet in thickness, and where the clay, which has good volume, lies either directly on or only a few feet above the limestone. The heavy sandstone found above the clay and limestone in Clay Township evidently correlates with that which lies above the clay in the Olive Hill region.

Harrison Township.—In the western part of Harrison Township, especially on Woods Ridge, the Sciotoville clay and the Maxville limestone are about on the same level. The clay, which has excellent thickness and purity, is overlain by a thick sandstone, which is the same stratum as that found in Clay Township, and probably at Olive Hill, Kentucky. These relations will be brought out by a few sections taken along the ridge. In the western part of Section 24, the Maxville limestone and Sciotoville clay are near the same level. Near the middle of this section the clay is shown as follows:

	Ft.	In.
Sandstone	20	--
Coal blossom, *Anthony*	--	1
Clay, flint, good quality, *Sciotoville*	4	--

On the Woods farm, in the eastern part of Section 24, the Maxville limestone is found just below the sandstone that forms the roof of the clay in the above section. The rock strata are as follows:

	Ft.	In.
Green clay and covered, *Sciotoville* horizon	2	--
Ore, nodular	--	4
Limestone, *Maxville*, reported thickness	3	--

South of the above, in Section 30, Harrison Township, on the Henry Rider property, the section is as follows:

	Ft.	In.
Coal blossom, *Anthony*	--	1
Clay, flint, good, *Sciotoville*	3	--
Shales and covered	23	--
Limestone, *Maxville*	1	6

In this region the Sciotoville clay is often many feet in thickness, and is made up of layers of semi-flint and flint clay with plastic clay above. The Maxville limestone is shown 23 feet below the Sciotoville clay, while on Woods Ridge, one mile north, it is practically on the same level as the clay. In this locality the overlying sandstone is also separated from the Sciotoville clay by about 20 feet of shales. On the property of the Scioto Fire Brick Company, in Section 32, the clay bed in local areas has a shaly sandstone for a roof, which is a continuation of that seen on Woods Ridge. The Anthony coal is usually found above the clay, but it seldom thickens to more than a few inches. In parts of this section the sandstone phase of the Sharon conglomerate was noted, and at a few places the brecciated Harrison ore was exposed below the conglomerate. The record obtained gives the following relations:

	Ft.	In.
Coal, *Anthony*	--	6
Clay, flint, and semi-flint, *Sciotoville*	3	6
Shales and covered	38	--
Ore, *Harrison*	2	--
Sandstone and shales, *Logan*	100	--

In the cut of the Baltimore & Ohio Southwestern Railroad, in

Section 36, near the residence of Isaac Graham, the following measurements were taken:

		Ft.	In.
Shale, blue, part siliceous		27	--
Coal, dense	*Anthony*	--	4
Shale		--	2
Coal, dense		--	7
Clay, flint, with scattered quartz pebbles, *Sciotoville*		5	6
Conglomerate, *Sharon*, quite pebbly		20	--

The Sharon conglomerate found in this locality is very pebbly, and may be traced from here with but few breaks northward across Harrison and Madison townships, where the deposits reach a thickness of 55 feet or more; thence across Scioto Township, Jackson County, to Liberty Township, where cliffs of conglomerate 150 feet in thickness are exposed, and where the Sharon coal above has good volume; thence eastward across this township to Lick, where both the Sharon and Quakertown coals are well developed, and were first mined in southern Ohio. Also from Liberty Township it may be traced eastward into Coal Township, where the Quakertown coal has been mined extensively, or northward across Jackson Township into Vinton County. In the above section the Sciotoville clay lies directly on the Sharon conglomerate, but north of this, in the same county, and also in Jackson, the two members are usually separated by an interval of many feet.

Near the above section, the rocks exposed along the road south of Perry Loutherback's house show the brecciated zone at the contact between the Logan and Pottsville rock. The section measured follows:

		Ft.	In.
Pottsville formation.			
Sandstone, cross-bedded		13	--
Disconformity.			
Coal, bony, *Anthony*		--	6
Clay, dark, plastic, *Sciotoville*		1	8
Disconformity.			
Sandstone, with pebbles near bottom	*Sharon*	8	--
Shale, soft, irregular		2	8
Sandstone, with scattered pebbles		10	--
Conglomerate zone, material made up of quartz pebbles, flint nodules, iron ore, with clay and shaly material, *Harrison*		2	--
Disconformity.			
Logan formation.			
Shale, sandy		5	--

The conglomerate below the base of the Sharon here has the same position as that found at many places west of the Little Scioto River, and it represents the erosion products from the Maxville limestone. This relation places with certainty the Maxville limestone below the Sharon conglomerate. The same relation of the two conglomerate beds was noticed at other places north of this also. The Anthony stone are about on the same level. The clay, which has excellent thickness and purity, is overlain by a thick sandstone, which is the same stratum as that found in Clay Township, and probably at Olive Hill, Kentucky. These relations will be brought out by a few sections taken along the ridge. In the western part of Section 24, the Maxville limestone and Sciotoville clay are near the same level. Near the middle of this section the clay is shown as follows:

	Ft.	In.
Sandstone	20	--
Coal blossom, *Anthony*	--	1
Clay, flint, good quality, *Sciotoville*	4	--

On the Woods farm, in the eastern part of Section 24, the Maxville limestone is found just below the sandstone that forms the roof of the clay in the above section. The rock strata are as follows:

	Ft.	In.
Green clay and covered, *Sciotoville* horizon	2	--
Ore, nodular	--	4
Limestone, *Maxville*, reported thickness	3	--

South of the above, in Section 30, Harrison Township, on the Henry Rider property, the section is as follows:

	Ft.	In.
Coal blossom, *Anthony*	--	1
Clay, flint, good, *Sciotoville*	3	--
Shales and covered	23	--
Limestone, *Maxville*	1	6

In this region the Sciotoville clay is often many feet in thickness, and is made up of layers of semi-flint and flint clay with plastic clay above. The Maxville limestone is shown 23 feet below the Sciotoville clay, while on Woods Ridge, one mile north, it is practically on the same level as the clay. In this locality the overlying sandstone is also separated from the Sciotoville clay by about 20 feet of shales. On the property of the Scioto Fire Brick Company, in Section 32, the clay bed in local areas has a shaly sandstone for a roof, which is a continuation of that seen on Woods Ridge. The Anthony coal is usually found above the clay, but it seldom thickens to more than a few inches. In parts of this section the sandstone phase of the Sharon conglomerate was noted, and at a few places the brecciated Harrison ore was exposed below the conglomerate. The record obtained gives the following relations:

	Ft.	In.
Coal, *Anthony*	--	6
Clay, flint, and semi-flint, *Sciotoville*	3	6
Shales and covered	38	--
Ore, *Harrison*	2	--
Sandstone and shales, *Logan*	100	--

In the cut of the Baltimore & Ohio Southwestern Railroad, in

Section 36, near the residence of Isaac Graham, the following measurements were taken:

		Ft.	In.
Shale, blue, part siliceous		27	--
Coal, dense	*Anthony*	--	4
Shale		--	2
Coal, dense		--	7
Clay, flint, with scattered quartz pebbles, *Sciotoville*		5	6
Conglomerate, *Sharon*, quite pebbly		20	--

The Sharon conglomerate found in this locality is very pebbly, and may be traced from here with but few breaks northward across Harrison and Madison townships, where the deposits reach a thickness. of 55 feet or more; thence across Scioto Township, Jackson County, to Liberty Township, where cliffs of conglomerate 150 feet in thickness are exposed, and where the Sharon coal above has good volume; thence eastward across this township to Lick, where both the Sharon and Quakertown coals are well developed, and were first mined in southern Ohio. Also from Liberty Township it may be traced eastward into Coal Township, where the Quakertown coal has been mined extensively, or northward across Jackson Township into Vinton County. In the above section the Sciotoville clay lies directly on the Sharon conglomerate, but north of this, in the same county, and also in Jackson, the two members are usually separated by an interval of many feet.

Near the above section, the rocks exposed along the road south of Perry Loutherback's house show the brecciated zone at the contact between the Logan and Pottsville rock. The section measured follows:

		Ft.	In.
Pottsville formation.			
Sandstone, cross-bedded		13	--
Disconformity.			
Coal, bony, *Anthony*		--	6
Clay, dark, plastic, *Sciotoville*		1	8
Disconformity.			
Sandstone, with pebbles near bottom	*Sharon*	8	--
Shale, soft, irregular		2	8
Sandstone, with scattered pebbles		10	--
Conglomerate zone, material made up of quartz pebbles, flint nodules, iron ore, with clay and shaly material, *Harrison*		2	--
Disconformity.			
Logan formation.			
Shale, sandy		5	--

The conglomerate below the base of the Sharon here has the same position as that found at many places west of the Little Scioto River, and it represents the erosion products from the Maxville limestone. This relation places with certainty the Maxville limestone below the Sharon conglomerate. The same relation of the two conglomerate beds was noticed at other places north of this also. The Anthony coal, about 10 inches in thickness, is well shown in the mines of the Scioto Fire Brick Company, near Gephart Station.

Bloom Township.—In western Bloom Township the Sciotoville clay is quite steady, and has good volume and high purity. The Anthony coal, although thin and usually impure, is as persistent as the clay, and is found lying directly above it. Still higher in the geological column another coal bed is present in the vicinity of Scioto Furnace. This coal has the same stratigraphic position as the known Quakertown coal in the Jackson County fields, and is evidently correlative with it. At a few places, also, a thin impure coal is found lying directly above the Sharon conglomerate. The relation of the coal to the conglomerate is the same as that found in Jackson County, where this coal bed has long been known as the Sharon coal. These various relations will be given in more detail by adding a few sections of the rocks in the western part of this township.

In Section 20, just north of the clay mill of the Harbison-Walker Refractories Company, the Bear Run coal, which is later discussed, was mined for local use at Scioto Furnace. The thickness of the bed is reported by Ollie Downing to be from 1 foot 3 inches to 4 feet. This coal from this place to the town of Jackson is more persistent and better developed than the Quakertown coal; hence it is an important aid in determining the positions of other members. The section obtained is recorded below:

	Ft.	In.
Shales, dark	13	--
Coal, *Bear Run*, reported thickness	3	--
Covered	3	--
Sandstone, massive	7	--
Covered, probably sandstone	8	--
Sandstone	13	--
Shales and covered	31	--
Coal, *Anthony*	--	2
Clay, flint and semi-flint, *Sciotoville*	5	--
Covered	2	--
Sandstone, *Sharon*	15	--

In Section 21 a coal bed, which is called with some confidence Quakertown, has been mined in a small way. At this place the interval from the Sciotoville clay to the overlying coal is nearly the same as it is in sections 6 and 7, Coal Township, Jackson County. Measurements made on the land of Henry Moore follow:

	Ft.	In.
Coal, solid block, *Quakertown*	1	5
Shale and covered	31	--
Ore, *Guinea Fowl*	--	6
Shale	6	6
Coal, *Anthony*	--	2
Clay, flint Clay, semi-flint } *Sciotoville*	3	--

In Section 16, Bloom Township, a composite section from a drill record made near the Baltimore & Ohio Southwestern Railroad, and from measurements taken north of this on the William Tripp property, is as follows:

	Ft.	In.
Ore, *Lower Mercer* or *Little Red Block*	--	4
Shale and covered	44	--
Ore, *Boggs*, reported thickness	1	--
Shale and covered	36	--
Bluish limestone, nodular, with calcite	1	--
Shale	10	--
Coal, *Vandusen*, reported thickness	2	3
Shale	8	--
Sandstone	11	--
Shale	3	--
Sandstone	5	--
Covered	27	--
Coal, *Bear Run*, reported thickness	1	5
Sandstone	6	--
Shale and covered	10	--
Top of drill hole.		
Surface	5	--
Shale, sandy	5	6
Shale, black } *Quakertown*	--	6
Coal	--	6
Clay mixture	8	--
Shale, black	1	--
Sandstone, shaly	5	6
Shale, sandy	3	--
Shale	26	--
Bone coal, *Anthony*	--	4
Clay, *Sciotoville*, flint and semi-flint, part sandy	9	8
Shale, black	1	--

The above section is of interest, as it shows 4 important members between the Sciotoville clay and the Lower Mercer ore, and as it shows approximately the normal intervals of separation of the beds as they occur in eastern Scioto County. The upper members are of aid often in establishing the positions of members below.

On the William Tripp property, in the southwestern part of Section 7, the Sciotoville clay has good volume and high purity. Above the clay a coal bed, which is the same as that mined on the Moore land near Scioto Furnace, has been prospected, while below the clay another stratum of coal was exposed in the bed of a small stream. This lower coal, which lies directly above the Sharon conglomerate, correlates with the Sharon coal of Jackson County. If this placing of the beds is correct, then the position of the Sciotoville clay is between the Sharon and Quakertown coals. The section obtained on the Tripp land follows:

	Ft.	In.
Coal, *Quakertown*, reported thickness	1	4
Shales and covered	35	--

	Ft.	In.
Clay, flint, *Sciotoville*	3	--
Sandstones, shales and covered	32	--
Coal, *Sharon*, reported thickness	1	8
Sandstone, with a few pebbles, *Sharon*	4	--

One mile north of the above locality the Sharon coal has been opened and a small amount mined. The Sciotoville clay was not found at this place, so no good section was obtained. Near the Baptist Church, on Bear Run, in Section 5, Bloom Township, the rocks exposed measured as follows:

	Ft.	In.
Flint clay, *Sciotoville*, seen on outcrop	2	--
Covered	15	6
Shale, gray	10	--
Clay shale, black, plastic	5	6
Shale, gray, sandy	14	--
Ore, kidney, *Sharon*	--	6
Shale, gray, somewhat fissile	1	--
Clay shale, black, plant marked, *Sharon* coal horizon	1	6
Shale, gray, soft	10	6
Sandstone, shaly } *Sharon*	3	--
Sandstone, with pebbles } *Sharon*	3	--
Covered	10	--
Sandstone, *Vinton*	4	--

As the members are traced northward, the interval separating the Sharon conglomerate and Sciotoville clay expands. In the above section the interval is 58 feet, while in the record on the Tripp property, in Section 7, it is 32 feet. As previously shown, at Gephart Station, the Sciotoville clay lies directly on the Sharon conglomerate, and even the quartz pebbles are present in the clay. This pronounced irregularity of the members at the base of the Pottsville formation extends from the Ohio River northward into Vinton County, where the present survey work ended.

On Bear Run, one-half mile east of the Baptist Church, in Section 4, Bloom Township, on the William Tripp property (William Kinker tract) the following rocks were measured:

	Ft.	In.
Coal blossom, *Bear Run*	--	6
Clay, shaly, dark	3	6
Shales, gray, and parts covered	28	--
Sandstones, thin and medium bedded	13	--
Coal, *Quakertown*, thickens to south	1	8
Shales and covered	33	--
Sandstones	7	--
Coal, *Anthony*	--	2
Clay, flint, dark, *Sciotoville*	6	--
Covered	10	--
Shales, *Vinton*, unmeasured.		

In the above section the Sciotoville clay again lies close to the rocks of the Logan formation, which, in the Dever Valley north of this locality, extends into the Pottsville formation to the horizon of the Bear Run coal. The intervals to the Quakertown and Bear Run coals are slightly above normal, but both coals in areas adjacent to that where the record just given was obtained are quite well developed, and have been mined for local needs. One-half mile east of the above section, the Bear Run coal has been worked in a small way for years. A section taken on the William Tripp property shows the following relation of this coal to the Sciotoville clay:

		Ft.	In.
Coal, somewhat bony, cannel at times	*Bear Run*	--	10
Coal, good		1	6
Clay		1	--
Covered		8	--
Sandstone, thin and medium bedded		14	--
Covered		35	--
Shale		3	--
Coal blossom		--	1
Clay, dark, shaly	*Sciotoville*	9	--
Ore			3
Clay, flint, sandy		2	--

As the Sciotoville clay in the territory covered by the preceding sections is quite persistent and readily identified wherever found, the positions of the various members present are established with confidence. From here northward, the deposits of Sciotoville clay are more scattered, but the member may be followed with a degree of certainty by exposures noted in Madison Township, Scioto County, and in Hamilton and Scioto townships, Jackson County, to the Sharon and Quakertown coal fields in Liberty, Lick, and Coal townships.

In Section 3, on the H. H. Stevenson property, the Bear Run coal was exposed for measurement. As this coal is somewhat steady from this locality to the town of Jackson, and as the fossiliferous shales above it also aid in stratigraphic work, this member will be frequently used; hence the following section is given to show the character of the coal bed and the associated shales:

	Ft.	In.
Sandstone, massive	6	--
Shale, blue, lower part fossiliferous	7	--
Coal, *Bear Run*, upper few inches impure	2	4
Clay, unmeasured.		

The fossils in this shale were identified by Clara G. Mark as *Lingula tighti*, Herrick.

Madison Township.—In Madison Township the Sciotoville clay is well developed only in local areas, but where present it is flint or semi-flint clay of the best qualities. The Sharon coal, however, begins to appear in better character than in the townships previously considered, while the Sharon conglomerate, especially in the eastern part of the area, forms massive cliffs along the courses of the streams. A few measurements will be given in order to show the various relations of the beds under consideration. In Section 26 the upper part of the rocks exposed on the land of Samuel Shoemaker, is recorded below:

	Ft.	In.
Clay, flint, *Sciotoville*	3	--
Shales and covered	24	--
Shales	10	--
Shales and covered	9	--
Coal, *Sharon*	--	4
Clay, bluish, tough	2	--
Covered	6	--
Sandstone, light, fine-grained	7	--
Ore, *Harrison*	1	--
Sandstone, *Vinton*	6	--

On the R. A. Dever property, in Section 20, the Anthony coal and Sciotoville clay are shown as follows:

	Ft.	In.
Ore, *Guinea Fowl*, sandy, with pebbles	--	4
Shales, dark	6	--
Coal, good, *Anthony*	3	--
Clay, sandy, *Sciotoville*	4	--
Covered	20	--
Shales and sandstone, *Vinton*	15	--

Due west, across the hollow, the coal is thinner, but the clay is thicker and is of excellent quality.

In Section 11, south of the White Gravel Church, on land of Francis Warren, the record obtained shows the Sharon ore, coal, and conglomerate, the Sciotoville clay, and the Anthony coal. The measurements are given below:

	Ft.	In.
Coal, *Anthony*	1	3
Clay, dark, plastic, *Sciotoville*, flint clay seen to west across hollow on this horizon	3	--
Covered	16	--
Shale	2	--
Ore, *Sharon*	--	10
Covered	8	--
Sandstone	2	--
Coal blossom, *Sharon*, reported thickness of coal and partings	3	--
Covered	5	--
Conglomerate, *Sharon*	65	--
Covered	5	--
Shale	2	--
Conglomerate of *Allensville*	1	--

In Section 5, on the land of Charles Phleger, the Sciotoville clay has good volume and high purity, while the Sharon conglomerate is quite thick and characteristically pebbly. A thin coal bed, which was noted also at other places in this vicinity, lies close above the conglomerate, and it is considered correlative with the thick deposits of

Sharon coal in Jackson and Pike counties. The section measured at this place follows:

		Ft.	In.
Clay, flint, good quality	*Sciotoville*	2	8
Clay, light, plastic		1	--
Shale and covered		35	--
Coal blossom, *Sharon*		--	6
Clay and covered		15	--
Conglomerate, *Sharon*		55	--
Sandstone, *Vinton*		20	--

Jefferson Township.—The Sciotoville clay is present on only a few of the high knobs on the main ridges in Jefferson Township, and as a general thing it lies close to the Logan rocks below. In some localities a sandy phase of the Sharon conglomerate occurs, but the Sharon coal was not found at any place in good development, although dark carbonaceous shales, which mark the horizon, were seen in a few localities. A record taken on the land of Joseph R. Keller, in Section 26, illustrates relations somewhat similar to those found in Madison Township:

	Ft.	In.
Coal blossom, *Anthony*	--	6
Clay and clay shale	9	6
Clay, flint, *Sciotoville*, good quality	1	3
Sandstone, ferruginous	--	6
Sandstone, light, soft	1	3
Sandstone	1	--
Shale, sandy	7	--
Sandstone, shaly	20	--
Sandstone, massive, part covered	13	--
Covered	8	--
Coal blossom, dark clay with coal bands, *Sharon* coal horizon	4	--
Covered	30	--
Shale and sandstone, *Logan*	20	--

PIKE COUNTY

In its extension northward, from Scioto County into Pike, the Sciotoville member becomes more patchy, but the bed is at once recognized by the marked characteristics of the clay. The Sharon conglomerate in eastern Pike County is massively developed, often exceeding 100 feet in thickness, and is distinctive on account of the high percentage of quartz pebbles. Farther in this area the Sharon coal begins to appear in force, and it extends with but few wants from the eastern part of Pike County to the town of Jackson. Owing to the rise of the rocks to the west, the Quakertown coal, which is highly developed in Jackson County, passes above the summits of the highest hills in the area under discussion. Records obtained in Pike County will be given in order to show the extent of the Sciotoville clay and its relations to the Sharon coal and conglomerate.

Union Township.—The horizon of the Sciotoville clay, and of the Sharon coal is confined to high knobs in Union Township. The Sharon coal has been mined for local needs in Section 19, and is reported to be about 2 feet in thickness. In this locality this coal bed lies on the thick Sharon conglomerate, parts of which are composed largely of quartz pebbles. The following record, taken on the Jacob Frazer property, in Section 19, marks the position of the Sciotoville clay with reference to the Sharon coal and conglomerate:

	Ft.	In.
Clay, flint, *Sciotoville*, seen on outcrop	1	--
Covered	30	--
Coal, *Sharon*, reported thickness	2	--
Covered	3	--
Conglomerate, *Sharon*	20	--

The Sharon coal here has been mined for local use and is reported to be from 20 to 28 inches in thickness.

Jackson Township.—The position of the Sharon coal with reference to the Sharon conglomerate in eastern Pike County is well illustrated by measurements taken on the land of J. W. Overly, in Section 2, and given below:

	Ft.	In.
Coal, *Sharon*	2	4
Clay, siliceous	1	--
Conglomerate, *Sharon*	140	--
Sandstones and shales, *Vinton*	65	--

The massive Sharon conglomerate extends in an unbroken sheet over a large area in Jackson Township, and the Sharon coal is somewhat steady. Near Allen Chapel, in Section 2, the bed which has been mined is overlaid by a conglomerate sandstone, above which the Sciotoville clay is found only a short distance north of the mines This relation places the Sciotoville clay above the Sharon coal, but the exact interval separating the two beds was not obtained.

JACKSON COUNTY

Although only scattered pockets of high-grade flint clay are found in Jackson County, these are sufficiently continuous to show that they are fragments of the Sciotoville member. The Sharon conglomerate is very thick in the western part of the county, especially in Liberty Township, where the deposits often measure between 100 and 200 feet in thickness. Just above this bed the Sharon coal is found, and it has good volume and continuity over a large area. From Scioto and Pike counties this coal may be traced with few wants to the original Sharon coal field under the town of Jackson, just north of which the Quakertown coal appears in force, and extends northward in an unbroken sheet to Vinton County. The Bear Run coal, somewhat steady, but usually thin, is also present in the vicinity of Jackson. By this overlapping of the beds their stratigraphic positions may be determined with confidence; hence records obtained in Jackson County will be given in order to bring out these relations in detail.

Hamilton Township.—The Sciotoville clay is found at a few places in Hamilton Township, but the Sharon and Quakertown coals are scarcely represented. However, the Bear Run coal has good volume in the southern part of the township, and may be used for a bench mark in stratigraphic work. In the Dever Valley, the Sciotoville clay was found at three places, and it lies about 80 feet below the Bear Run coal. The Sciotoville clay, with the Anthony coal above it, was noted along the road near the head of Little Bucklick Creek, in Section 4. This coal was exposed also along the streams in the vicinity of the village of Mabee. It is from 1 to 2 feet in thickness.

Scioto Township.—The conditions of the members near the base of the Pottsville formation in Scioto Township are much the same as they are in Hamilton. Near Grahamsville, in Section 27, the flint clay was exposed in the bed of a tributary of Sugarcamp Creek, while above it, plastic clays with thin impure coal beds were also uncovered. The positions of the Sharon conglomerate, Sciotoville clay, Anthony coal, and other members higher in the geological column are shown in the following section obtained at this place:

		Ft.	In.
Shale		2	--
Coal, *Vandusen*		--	6
Sandstone, argillaceous		3	--
Sandstone, light		3	6
Ore, sandy	*Jackson Sand Block*	1	2
Shale		1	5
Ore, sandy		--	6
Sandstone, thin-bedded, ferruginous		6	--
Shale		26	--
Coal blossom		--	4
Clay, plastic, dark		1	6
Shale		6	--
Sandstone, irony, plant marked		1	--
Shale		16	--
Sandstone, thin, flaggy, with shale partings		13	--
Coal and dark carbonaceous shale, *Anthony*		2	--
Clay, light, sandy		1	6
Shale		1	--
Thin sandstone and shale layers		2	7
Shale, blue		--	5
Coal, bony		--	1
Clay, light, plastic, part "pink eye"	*Sciotoville*	4	4
Clay shale, dark		3	8
Clay shale and covered		5	--
Coal		--	1
Clay, flint, sandy		1	6
Covered		20	--
Conglomerate, *Sharon*		10	--

In Section 9, the Sciotoville member, represented by a hard flint clay of excellent quality, has been mined on the property of Fred Flaker, and the Sharon coal opened on that of William B. Pratt. The positions of these members are shown in the record given below:

	Ft.	In.
Clay, flint, *Sciotoville*, reported thickness	2	--
Sandstone	2	--
Shales and covered	35	--
Coal blossom, *Sharon*, seen on next hill 3 feet thick	1	--
Covered	18	--
Conglomerate, *Sharon*	24	--

As these beds extend northward across the preglacial California Valley the Sharon coal becomes more steady, but the Sciotoville clay continues patchy; further, the Sharon conglomerate is very constant. On the Sawyer property, in Section 7, the Sciotoville member is marked by a thick deposit of plastic and "pink eye" clay, while the Sharon coal and conglomerate have the characteristic development of the regions northward and described under Pike County. The measurements taken on the Sawyer farm are given below:

	Ft.	In.
Ore, *Guinea Fowl*	--	6
Shale and covered	5	--
Coal blossom, *Anthony*	--	2
Clay, plastic, *Sciotoville*, lower part "pink eye"	13	8
Sandstone, massive	11	--
Shale	13	6
Coal, *Sharon*	2	6
Covered	14	--
Conglomerate, *Sharon*	16	--

The Sciotoville clay and Sharon coal are both well developed on the Robert Lamb property, in Section 6, where the following record was obtained:

	Ft.	In.
Coal blossom, *Anthony*, not measured.		
Clay, flint and semi-flint, *Sciotoville*	6	--
Covered	32	--
Sandstone	5	--
Coal, *Sharon*	2	4
Covered, probably conglomerate	10	8
Conglomerate, *Sharon*	26	--

In this locality the Sharon coal has been mined for years, and from here it may be traced with but few wants to the Jackson field, where it has its maximum development in southern Ohio. This section further establishes the position of the Sciotoville clay with regard to that of the Sharon coal. The section on the Lamb property was practically duplicated by another taken on the land of Joseph West, in the eastern part of the same section.

Liberty Township.—The Sharon conglomerate has its maximum development in Liberty Township, while the overlying Sharon coal has excellent volume and continuity. The Sciotoville clay is poorly represented, and only outliers of Quakertown coal, which extends as far west as the eastern part of Section 10, are found. The relations of the deposits here, however, fix with certainty the stratigraphic positions of the members near the base of the Pottsville formation. In Section 13, on the land of Louis Ray, the Sharon and Quakertown coals have both been mined and have normal development. The Sciotoville clay is found in the interval between the two coal beds, but at this place it lies closer to the Sharon coal, than where noted in Scioto Township. The Sharon conglomerate is massively developed also in this locality; hence the Sharon conglomerate, Sharon coal, Sciotoville clay, and Quakertown coal are all found in the same section, the measurements of which are given below:

		Ft.	In.
Coal, *Quakertown*, reported thickness		2	6
Covered		58	--
Sandstone		10	--
Clay, flint, good quality	*Sciotoville*	1	2
Clay, plastic		1	10
Coal blossom, *Sharon*		1	--
Clay, dark, sandy		2	--
Conglomerate, *Sharon*		91	--

The Sharon coal has been mined here by the Star Furnace Company, and it is reported to be 3 feet in thickness and very irregularly bedded; that is, it is subject to rolls and dips. The Sciotoville clay is reported to form the roof of the coal in parts of the mine.

In the eastern part of this section, on the land of David Nicholls, both the Sharon and Quakertown coals in good development are found in the same hill. Both beds have been mined, and have about normal thickness. The interval separating the coals here is slightly greater, approximately 10 feet, than it is on the Ray farm. This may be due, however, to the fact that the Sharon coal conforms to the irregularity of the upper surface of the underlying conglomerate, which is everywhere more or less undulating. The section is important, for it extends the Sharon coal close to the original field under Jackson and the Quakertown coal to a place where it may be traced with certainty to the great field extending from Jackson to north of Wellston. The Sharon conglomerate is also present in force. The record obtained follows:

	Ft.	In.
Coal, *Quakertown*	2	6
Clay and covered	24	--
Sandstone, massive	33	--
Covered	5	--
Shale, with parts covered	19	--
Coal, *Sharon*	2	8
Covered	2	--
Conglomerate, *Sharon*	40	--

In the northern part of Liberty Township, in the vicinity of the Pine School, the Quakertown coal is found in the high knobs on the main ridge. The Sharon coal is poorly developed, but its position just above the Sharon conglomerate is still marked by a few inches of bony coal. About midway in the interval between these coal beds a siliceous flinty clay, which is evidently correlative with the Sciotoville member, occurs, and is overlaid by a ferruginous pebbly sandstone which appears to represent a very siliceous phase of the Guinea Fowl ore. The measurements taken on the property of D. D. Edwards, in Section 2, show the position of the beds, and are given below:

	Ft.	In.
Coal, *Quakertown*	3	6
Clay shale	1	6
Covered	42	--
Sandstone, ferruginous	2	--
Sandstone, ferruginous, with large pebbles	1	--
Clay, flinty, siliceous, *Sciotoville*	1	6
Sandstone, clay-bond, soft, light	10	6
Sandstone and covered	23	--
Shale and thin ferruginous sandstone	5	--
Sandstone, shaly	5	--
Shale, blue	7	--
Coal, shaly, *Sharon*	--	4
Clay shale	2	6
Covered	4	--
Conglomerate, *Sharon*	90	--

Coal Township.—The best part of the original field of Quakertown coal was in Coal Township. Although poorly developed the Sharon coal is sufficiently well marked by patches of coal so that the horizon may be followed with some degree of certainty, while in the localities where due the Sharon conglomerate is present in force. The Sciotoville bed is defined by small isolated areas of high-grade flint clay. Further, the Anthony coal was first described from observations made on the Samuel Anthony land, in Section 6. Important relations of these members in this township will now be considered in more detail.

Near the village of Bierlytown, in Section 7, on the land of Arthur Howe, both the Quakertown coal and Sciotoville clay have normal volume. The position of the Sharon coal is marked by black carbonaceous shales with thin coal bands. The record measured at this place, and given below, places the Sciotoville clay between the two coal deposits:

	Ft.	In.
Coal, *Quakertown*	1	3
Covered	31	--
Shale, with thin sandstone layers	13	--
Clay, flint, *Sciotoville*, good quality	5	--
Covered	9	--
Sandstone, massive	11	--

	Ft.	In.
Shale	3	--
Shale, black, with parts covered, *Sharon* coal horizon	8	--
Clay shale, light, siliceous	5	--
Covered	37	--
Conglomerate, *Sharon*	25	--

East of the above, on the farm of Louis Mapes, the two coals and the clay were also exposed. The Sciotoville clay, which was seen on the outcrop, is reported to be 3 feet in thickness under cover. It is a high-grade flint clay, and in every respect it is similar to the flint clay found in the Sciotoville and Olive Hill fields. The section, although duplicating in the main that given above, will be recorded, as it extends the members into the region where the Quakertown coal exists as a continuous sheet to the Wellston field.

	Ft.	In.
Coal, *Quakertown*	3	--
Covered	38	--
Clay, flint, *Sciotoville*, reported thickness	3	--
Covered	21	--
Sandstone, with a few scattered pebbles	27	--
Coal, *Sharon*	1	--
Clay, dark, siliceous	3	--

A deposit of high-grade flint clay was exposed along the road in Section 6. Above it there is also present the blossom of a coal, which has been mined in a small way. Concerning these E. B. Andrews said:[1]

> On the land of Charles McKinniss, near the southeast corner of Section 6, Coal (formerly Lick) Township, is a seam of coal which I am led to believe is the equivalent of the "Anthony" seam. The seam is 3 feet thick, with a reported stratum of coal 14 inches thick underneath, separated by 4 inches clay slate. The coal seen is of very superior quality. The lower part is not mined, being considered very slaty.

The following is a section of strata seen near Mr. McKinniss' land:

	Ft.	In.
Clay shales	10	--
Coal	3	--
Clay slate, reported	--	4
Coal, slaty, reported	1	2
Not seen	9	--
Fire clay, very hard and good	3	--
Not seen	8	--

The coal of the above section is Anthony, and the clay belongs to the Sciotoville. On the hill above this clay and coal the Quakertown bed has been worked by railroad mines. The section was remeasured by the writer in order to obtain the interval to the Quakertown coal. The measurements found are given below:

	Ft.	In.
Coal, *Quakertown*	2	6
Covered	4	--

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[1] Geol. Surv. of Ohio, Report of Progress for 1870, p. 142.

	Ft.	In.
Sandstone	3	--
Coal	--	6
Clay, plastic	4	6
Shales, dark	6	--
Covered	8	--
Sandstone	2	6
Shales, gray	9	--
Coal blossom, *Anthony*	--	6
Covered	3	--
Coal blossom	--	2
Clay, flint, good, *Sciotoville*	3	6

Lick Township.—High-grade flint clay was not found in Lick Township, but in places siliceous plastic clays were exposed, which mark the horizon. The noted field of Sharon coal in southern Ohio is in the basin under the town of Jackson, while north of this large areas of Quakertown coal have been mined. The Bear Run coal with fissile ore and shale also appears northeast of Jackson. The intervals separating the Sharon and Quakertown coals in this locality are about the same as noted elsewhere. As the Sciotoville clay was not found in characteristic development, no sections showing the relation of beds will be given. However, the Bear Run coal will be considered as it is of interest on account of its aid in determining the stratigraphic positions of the Sciotoville clay and of other members on Holland Fork, in southern Jackson County, and on Bear Run, in northern Scioto County. The following record, which was about the average of a number of measurements, was taken at the Crescent mine, in Section 16:

		Ft.	In.
Ore, black band, fossiliferous	*Bear Run*	--	4
Coal		--	8
Bone shale, fissile		--	6
Covered and shale		23	8
Coal, *Quakertown*		2	6
Clay shale		3	--

The fossils in the ore are *Lingula tighti*, or the same as seen in the shale directly above the Bear Run coal on Bear Run, in Scioto County, and on Holland Fork, in southern Jackson County.

In a review of the sections given it is shown that the Sciotoville member, which carries the characteristic flint clay, not easily confused with other types, extends from the Ohio River in Scioto County to the Sharon and Quakertown coal fields of Jackson County. Although the flint clay is found only in pockets in Jackson County, the character and quality of the clay, the association of the plastic and "pink eye" clays, the relation of the conglomeratic Guinea Fowl ore, and the elevation of the beds, establish the identity of this bed with that found in the Sciotoville region, from where it can also be traced to the Olive Hill, Kentucky, flint clay fields. The Sciotoville member in Jackson County is also represented in many places only by plastic clays, but, owing to their similarity to plastic clays on other horizons, these clays were not considered in the preceding correlation. These sections establish the position of the Sciotoville clay, when the interval is normally developed, to be about midway between the Sharon coal and the Quakertown.

The position of the Anthony coal, which is quite persistent, but poorly developed, except in small isolated areas, is also defined. It lies either directly on or only a few feet above the Sciotoville clay, but it is not a sharply defined bed. The many sections given of this interval show that during the deposition of the clays small basins existed in which the conditions were favorable for the preservation of carbonaceous matter as coal. The Sciotoville member in some cases is made up of several benches of clays, separated by coal bands, which vary in thickness from a pencil mark to many inches, or, by black carbonaceous shales, which change to coal in other localities. The thickest coal is generally found near the top of the clay deposit. If the flint clay forms the upper layer of the deposit, the best developed coal lies on this, but if plastic clays are found above the flint, the thick coal lies either on these beds or between them. The best developed coal bed is called Anthony.

The recorded measurements show that the interval from the Sciotoville clay to the underlying Sharon coal is quite variable, owing largely to the fact that the coal lies, with few exceptions, on the Sharon conglomerate, the upper surface of which is subject to many irregularities. Further, they show that all of the Pottsville rocks below the Sciotoville clay, as they extend southward to the Ohio River, thin erratically, and in some places disappear completely. The Sharon coal in one locality is shown to lie either directly or only a few feet below the Sciotoville member, while this coal at another place is 70 feet below the clay. The average interval separating the beds, however, is about 40 feet. This variation in the interval, as previously stated, is due in the main to the influence of the Sharon conglomerate, above which the coal is bedded.

The Sharon conglomerate was deposited in a roll, and apparently it underwent either a depression in Jackson County, where the clay is usually found far above it, or an elevation in Scioto County, where in places, for example, in the vicinity of Gephart Station, the clay lies directly on the conglomerate bed. The evidence points to an elevation of the Sharon in Scioto County. The disconformity between the Mississippian and Pennsylvanian rocks is also illustrated by the sections. On Woods Ridge, in Scioto County, the Sciotoville clay is found at about the same elevation as the Maxville limestone, but north of this, in Pike and Jackson counties, the clay may be separated from the Logan rocks by as much as 150 feet. The lapse of time was equal at least to that required to deposit the Sharon conglomerate, Sharon clay and coal, and the 40 feet of sandstones and shale between the Sharon coal and the Sciotoville clay.

The sections show that the Quakertown coal lies above the Sciotoville clay. The interval varies from 35 to 59 feet, but averages about 43 feet. This coal bed is very thin where exposed in Scioto County, except near Scioto Furnace, in which locality it expands to a thickness of 1 foot 10 inches. In Jackson County it is prominent only in the area north of Jackson, where it attains the maximum thickness found in Ohio. In this field are found several pockets of flint clay, which thus definitely fixes the horizon at about 43 feet above the Sciotoville clay, and only a few feet less than this above the Anthony coal.

The Bear Run coal is found from the recorded sections to be from 62 to 86 feet above the Sciotoville clay. The average interval from this coal to the Sciotoville clay is 71 feet, or to the Quakertown coal 28 feet. On this horizon is found a fossil zone which is of some aid in the correlation of the members. The fossils were identified by Miss Clara Gould Mark as *Lingula tighti*. They are found in abundance in the shale directly over the Bear Run coal on Bear Run, in Scioto County, and on Holland Fork in southern Jackson County. Further, they are present in the black band ore in the coal bed exposed along the branch of Salt Creek, northeast of Jackson. This coal lies from 20 to 25 feet above the known Quakertown or Jackson Hill coal. The clay found on Holland Fork and Bear Run is undoubtedly Sciotoville, as it was traced with but few breaks to the fields at Scioto Furnace, and thence southward to Sciotoville. The regularity of the intervals, along with the aid of the fossil zone on the Bear Run horizon, thus fixes with certainty the position of the Quakertown and Bear Run coals with reference to the Sciotoville clay. The order of succession thus established is as follows:

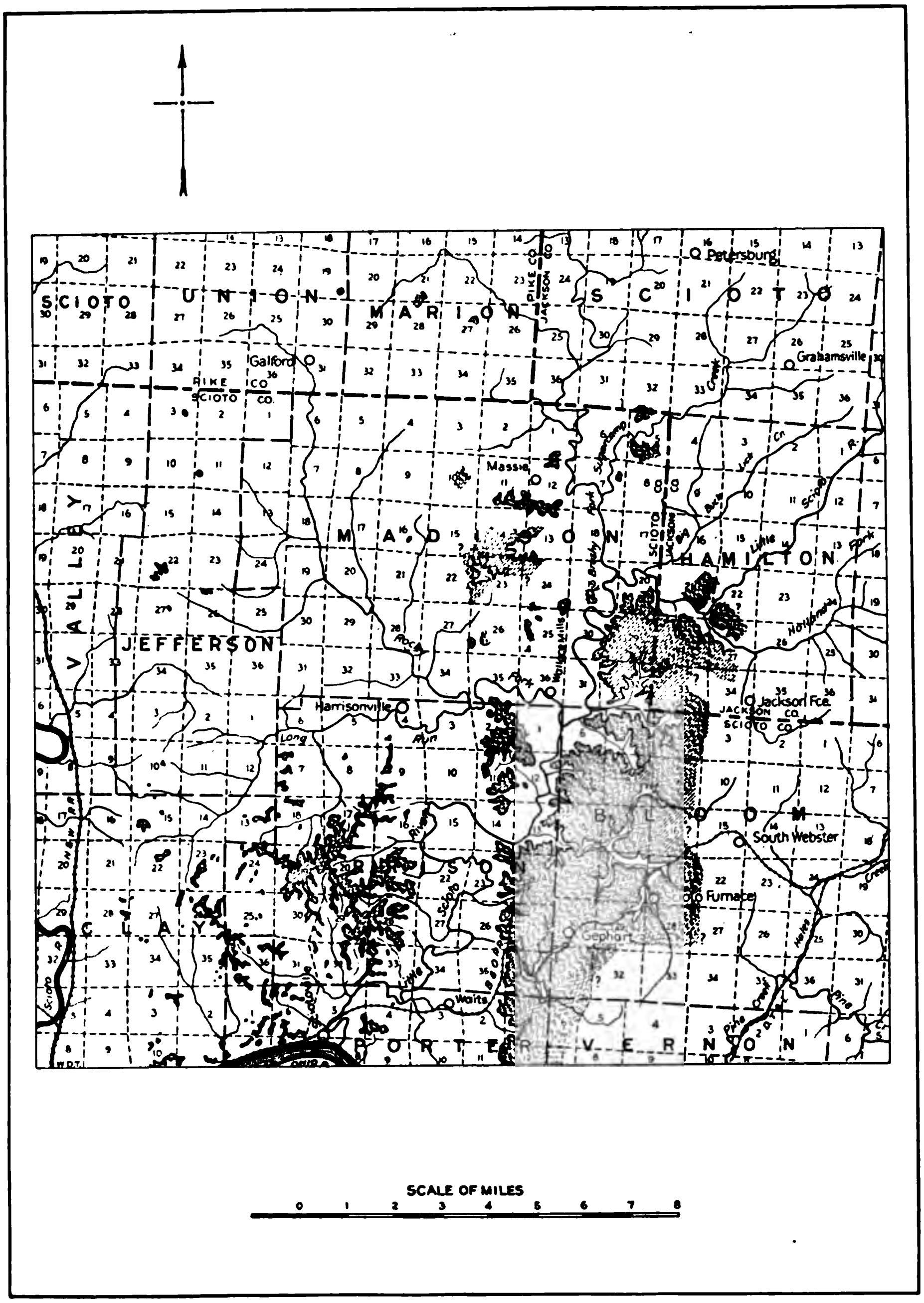
Bear Run coal.
Quakertown coal.
Anthony coal.
Sciotoville clay.
Sharon coal.
Sharon conglomerate.
Harrison ore.
Maxville limestone.

SCIOTOVILLE CLAY

Extent of Field

The area of high-grade Sciotoville clay in Scioto County is large. The deposits, however, are somewhat uncertain, as they may disappear at any time, or change to low-grade impure materials. In the eastern part of Clay Township this member is found on the main ridges at elevations from 900 to more than 1,000 feet; hence the area of good clay is small. The elevation of the Sciotoville clay in the western part of

MAP VIII.



Sciotoville Clay in Scioto County.

Porter Township is from 850 to 1,000 feet, which restricts the deposits to a small area. The clay, however, is practically continuous on the ridges, and is of good quality. In the eastern part of the township two pockets of good clay are found at an elevation of about 700 feet, one on the isolated hills immediately east of Sciotoville, and the other in the extreme northeastern corner of the same township. See Map VIII.

This member is above drainage in all of Harrison Township, but with the exception of a few scattered pockets the good clay is confined to the southern half. In the western part of the township, from Woods Ridge south to the Ohio River, exceptionally high-grade flint clay, which is seldom wanting, is found on this horizon. The elevation of the deposits on Woods Ridge is about 1,000 feet, while that of the beds along the western edge of the California Valley is about 800 feet. In the southeastern part of the township, along the Baltimore & Ohio Southwestern Railroad, and near the mouth of Frederick Creek, this member, represented by some good clay, is found at an elevation of about 700 feet above tide. In the western part of the township, north of Woods Ridge, only scattered pockets of flint clay are found on this horizon, the elevation of which is from 900 to 1,000 feet. In the northeastern part of the township, in the group of hills between the Little Scioto River and the old California Valley, the Sciotoville member, with an elevation of about 750 feet, is represented in a few places by good flint clay. In Vernon Township the Sciotoville clay is under cover. No drill records showing the character of the clay were obtained, but, as good clay is found both to the west and north, it is reasonable to expect at least some good material in this region.

The western part of Bloom Township is the center of the greatest activity in clay mining in the county. In fact, practically the whole supply of flint and semi-flint clays used by the three local firms is taken from this region. The area is large, the deposits are thick, and the clays are of most excellent quality. Along the western boundary the Sciotoville clay is found at an elevation of about 700 feet above tide. Dipping eastward it goes under cover near Gephart on the Baltimore & Ohio Southwestern Railroad, near Scioto Furnace on Frederick Creek, in Section 9 on Skull Creek, at Pinkerman on Laurel Lick Run, and in Section 4 on Bear Run. East of the outcrop, under heavy cover, but little is known of the character of these deposits. A drill hole, in which the clay is reported wanting, was put down at South Webster. In a well drilled in Section 29, on the Adam Brandt farm, 2 feet 10 inches of flint clay was found. From near South Webster to below Gephart, where the clay passes under cover, the deposit is thick and continuous and the strata are regular, which indicates that this is not the eastern edge of the field, but that it extends eastward under heavy cover. No prospecting has been done in the hills to the east of these places, or along the Pine Creek Valley.

From surface exposures noted, there is a clay field of some importance in Madison Township east of the California Valley. The deposits are found at an elevation of about 800 feet. Although the stratum is not continuous, and the member in only a part of the area is represented by flint clay of a good quality, the indicated yield of high-grade material is amply sufficient to support ceramic industries. In Jefferson Township the clay was found on a few isolated knobs on the main ridges that extend northward across the central part of the township and have an elevation of about 1,050 feet. The total area is small and unimportant. The Sciotoville clay was not observed in Valley Township.

Relations

The relations of the Sciotoville clay to the members below and above have been given in the general statement and correlation, but the relations of the different clays forming this member will here be treated more in detail. These separate clays differ in both their physical and chemical properties. The order, thickness, and composition of the different layers vary greatly from place to place. A pure flint clay, several feet in thickness, may go out completely in a few rods, or change to a very siliceous clay, or be replaced by plastic or semi-flint clay. In some localities the flint clay forms the upper layer of the deposit, while in other regions it is overlaid by several feet of plastic or semi-flint clay.

As previously stated, the position of the Sciotoville clay is about midway between the Sharon and Quakertown coals when the various rock strata in the interval have normal development. Further, the clay is overlaid by the Anthony coal, to which it bears the same relation as the Lower Kittanning clay bears to the Lower Kittanning coal. The horizon of the Sciotoville clay extends over most of that part of Scioto County east of the Scioto River, but the productive field is confined to limited areas in this territory, which will be considered now in a more definite way.

Clay Township.—In Clay Township the Sciotoville member is found near the summits of the highest knobs and ridges in sections 13, 14, 15, 22, 23, 26, 27, 28, 34, 35, 2, 3, 10, and 11. Although the clay areas are usually small, this field contributed for many years large quantities of most excellent material for the fire brick plants at Portsmouth and Sciotoville, but at present it is abandoned, owing to the fact that the best clay is largely exhausted, and that clay may be obtained more cheaply from other fields. A small productive area of Sciotoville clay is reported on the lands of the Peebles Paving Brick Company, in Section 11, where the following record was obtained:

	Ft.	In.
Shales	15	--
Clay, flint, siliceous, *Sciotoville*	3	6
Shales and covered	10	--
Sandstone, *Vinton.*		

The clay observed at other exposures in this locality is a true hard flint, quite free from detrimental siliceous and ferruginous impurities. On the main ridge in Section 13, the member was formerly worked by both drifting and stripping. A record obtained on the land of Isaac Ruby is given below:

	Ft.	In.
Pottsville formation.		
Sandstone, massive	8	--
Shales and covered	20	--
Clay, flint, good, *Sciotoville*	4	6
Shales and covered	24	6
Shaly sandstone	3	--
Shales, pink color	2	6
Logan formation.		
Sandstones and shales	140	--

In Clay Township, north of the above, and west of Munn and Long runs, the Sciotoville clay is confined to a few isolated hills on the main ridges, but east of these runs the stratum is generally present near the summits of the main ridges. In Section 22, on land of Ernest Cline, the Sciotoville clay and flinty Maxville limestone were seen on the outcrop. Mr. Cline reports the clay from 3 to 4 feet in thickness, and the interval to the underlying limestone from 8 to 12 feet. In this township the clay lies close to the Maxville or Logan rocks

Porter Township.—In Porter Township the Sciotoville member is well developed along the main ridges in sections 1, 6, and 36. The quality of the material is usually excellent. The deposits in this locality were among the first opened after the establishment of the brick industry (1864) in Scioto County, and have yielded a large quantity of high-grade material, but at present they are near exhaustion. The thickness of the bed varies from 1 foot to 14 feet, but the usual measurement is about 3 or 4 feet. The quality of the material is also variable, as it changes from hard pure flint and semi-flint clays to the siliceous and ferruginous types. Plastic and "pink eye" clays are not so well developed in this field as in that in Bloom Township. The member lies close to the underlying Logan sandstones and shales. The following record, taken in Section 36, shows the general structure of the bed:

	Ft.	In.
Coal, *Anthony*	--	5
Clay, flint, *Sciotoville*	3	6
Covered	15	--
Sandstone, *Vinton*.		

The Sciotoville clay has been worked for years in the isolated group of hills east of Sciotoville in sections 4 and 5. The plastic clay from this locality is of excellent quality. In the eastern part of the township the member is wanting or poorly developed, except at a few places in Section 1. On the Elizabeth Hurst farm, in this section, an outcrop exposure of the bed gave the following measurements:

	Ft.	In.
Coal, *Anthony*, reported thickness	1	2
Clay, flint, siliceous, *Sciotoville*	2	6
Sandstone, light, fine-grained	2	--

West of the above, on lands of C. Haselman and G. Bear, flint clay of good quality was formerly mined for the brick plants at Sciotoville.

Green Township.—The Sciotoville clay is poorly represented in Green Township, for flint clay of good quality was observed only at two places, which are at the head of Pattons Run and in the hollow south of Franklin Furnace. However, plastic and siliceous clays are more widely distributed, but are too impure or thin to be of special worth. The following measurements were made of the rocks exposed on Pattons Run on the land of H. Miller:

	Ft.	In.
Sandstone	7	--
Disconformity.		
Clay, flint, *Sciotoville*, good quality	2	--
Covered	10	--
Conglomerate, *Sharon.*		

The clay in this hollow is reported to vary in thickness from 1 to 4 feet. It is a hard clay and is quite free from deleterious material. The quality of the Sciotoville clay near Franklin Furnace, on the H. C. Feurt and A. J. Hyland properties, is somewhat variable, as a part of the bed is quite siliceous. In patches the high-grade flint clay is reported to expand to 4 feet, while the overlying plastic clay is stated to thicken to 7 feet. The section obtained at this place on the outcrop is recorded below:

		Ft.	In.
Coal, *Anthony*		--	2
Clay, plastic, light, good	*Sciotoville*	1	4
Clay, flint, light, good		1	--
Clay, flint, light, siliceous		2	6
Sandstone, clay-bond		1	6

Harrison Township.—The field of Sciotoville clay in the western part of Harrison Township was the main reliance for high-grade refractory materials used by the Sciotoville fire brick plants for many years. This field is not exhausted, but the best deposits have been largely worked out. The most important regions were Woods Ridge and the ridge extending from Niner Hill southeast to the Little Scioto River, in the southwestern part of Section 33. On Woods Ridge, in the western part of Section 24, the clay is of very fine quality, and the deposit usually quite thick. A section exposed is as follows:

	Ft.	In.
Coal blossom, *Anthony*	--	1
Clay, flint, good quality, *Sciotoville*	4	--

In this region the flint clay has a maximum thickness of about 6 or 7 feet, but the deposits have been drawn upon for many years; hence the quantity of clay yet available is not large. On the Henry Rider farm, in Section 30, the following record, which shows the interval from the Sciotoville clay to the Maxville limestone, was obtained:

	Ft.	In.
Coal blossom, *Anthony*	--	1
Clay, flint, good, *Sciotoville*	3	--
Shales and covered	23	--
Limestone, *Maxville*	1	6

In this locality the clay deposit, which is very thick in places, consists of semi-flint, flint, and plastic clay. The bed has been worked extensively by drift mines, which have fallen so that no section was obtained under heavy cover. On the lands of Albert Frazier and William Wenner, in Section 18, about 3 feet of good clay was exposed on the outcrop. North on this ridge heavy beds of plastic clays were found, but not measured. East of the California Valley, on the farm of Frank Cole, in Section 2, flint and "pink eye" clays of the Sciotoville member outcrop along the side of the hill, but they were not favorably exposed for measurement. Near Harrison Mills, on the Samuel Monroe property, in Section 12, this member was again noted. At this place the clay lies only about 22 feet above an iron ore, which probably represents the Harrison ore on the line of disconformity separating the Pennsylvanian and Mississippian series. The measurements obtained follow:

	Ft.	In.
Clay, flint, good, *Sciotoville*	6	--
Covered	2	--
Sandstone, fine-grained, white	5	6
Coal	--	2
Clay, dark, shaly	--	10
Sandstone, light, plant marked	1	10
Sandstone and covered	8	6
Covered	3	--
Ore, *Harrison*.		
Covered	10	--
Sandstone and shale, *Vinton*	40	--

At present the important field of Sciotoville clay in Scioto County is that east of the Little Scioto River, in the extreme eastern part of Harrison Township, and in the western part of Bloom.

On Plum Fork, in Section 36, from the Webster pike to the Baltimore & Ohio Southwestern Railroad, the clay outcrops in a number of places, but is generally siliceous. East of the creek the clay has been mined, and is reported by Jacob Bower to have good thickness and to be of good quality. He states that the maximum thickness of flint and semi-flint clay is 11 feet, but that the average measurement is much less than this.

Just east of Isaac Graham's residence, in the cut of the Baltimore & Ohio Southwestern Railroad, the Sciotoville clay was well exposed for measurement. The following record was obtained at this place:

		Ft.	In.
Shale, blue		27	--
Coal, dense	*Anthony*	--	4
Shale		--	2
Coal, dense		--	7
Clay, flint, *Sciotoville*, with scattered quartz pebbles		5	6
Conglomerate, *Sharon*		20	--

This bed has also been opened near Mr. Dill's house, and is reported by him to contain from 5 to 6 feet, with a maximum of 10 feet of flint and semi-flint clay. Further, he states, that the clay west of the railroad is patchy. This condition is indicated by a disconformity observed in the creek bed below John Neimer's house. In Section 25, on land of William Tripp (Meade farm), the Sciotoville clay has been mined more or less for several years. The area is large, and the thickness reported for the flint and semi-flint clay is from 2 to 6 feet.

Madison Township.—In Madison Township there is an undeveloped field of Sciotoville clay, which from the surface exposures noted is quite promising. The clay is of excellent quality, but the deposits are somewhat scattered. Thorough prospecting may show areas of sufficient size to justify the establishment of brick plants. On lands of William Tripp, in sections 29 and 32, the Sciotoville clay has been opened at several places. The deposits are from 2 to 8 feet in thickness and the clay is of good quality. On the farm of John Magnet, in Section 25, fine quality clay is exposed. There is a good outcrop of the clay on the hillside near the house, but this appears to have slipped from above, as the clay on the same hill east of this exposure is about 35 feet higher. The rocks exposed are given below:

	Ft.	In.
Shales	4	--
Clay, flint, good, *Sciotoville*	4	--
Covered	2	--
Sandstone, fine-grained, light	5	--
Shales and covered	25	--
Sandstone, massive, with pebbles near lower part, *Sharon*	45	--

Another exposure was seen on the hill to the north of this, but the thickness was not measured. This member is exposed again on the farm of Samuel Shoemaker, in Section 26, where the strata seen are as follows:

	Ft.	In.
Clay, flint, good, *Sciotoville*	3	--
Shales and covered	24	--
Shales	10	--
Shales and covered	9	--
Coal, *Sharon*	--	4

	Ft.	In.
Clay, blue, tough	2	--
Covered	6	--
Sandstone, light, fine-grained	7	--
Ore, *Harrison*	1	--

Surface exposures of the Sciotoville clay were noted in Section 19, on the land of Mrs. John N. Dever. In Section 24, on the property of George Mouga, the member was found as follows:

	Ft.	In.
Coal blossom, *Anthony*	--	8
Clay, plastic, good quality, *Sciotoville*	3	--
Shale and covered	8	--
Covered	39	--
Conglomerate, *Sharon*	8	--

On the William Kronk property, in Section 23, the following members were exposed:

		Ft.	In.
Clay, flint, fine quality	*Sciotoville*	2	2
Clay, dark, plastic, and "pink eye"		5	8
Shale, dark		3	--
Coal blossom, *Sharon*		2	6
Clay, dark, plastic		1	--
Covered		7	6
Sandstones, with shaly layers		24	--

This clay extends eastward also on land of Frank Debo. A thick deposit of highly colored "pink eye" clay was observed on the land of J. J. Shoemaker, in Section 18. No flint clay was found. Hard clay of excellent quality outcrops on the property of Mary Kronk, in Section 13, but it was not well exposed for measurement. In the northern part of the same section, on land of Oliver Powell, the following rocks were exposed:

	Ft.	In.
Clay, parts covered, flint, lower part sandy, *Sciotoville*	10	--
Covered	28	--
Conglomerate, *Sharon*	25	--

The surface exposures of clay in this locality indicate a heavy deposit, the upper part of which is quite pure, while the lower part contains some siliceous material. Along the road on the line of sections 12 and 13, near the home of E. H. Lyons, the Sciotoville clay was again noted. The record follows:

	Ft.	In.
Coal blossom, *Anthony*	1	--
Sandstone, light, shaly	8	--
Clay, flint, part sandy, *Sciotoville*	2	--

A surface exposure of good clay was also found east of the above on the land of Delmer Kronk. In Section 14, on the land of Jacob Seth, pieces of high-grade flint clay were observed on the outcrop 85 feet below the high knob near his home. In Section 12, north of Millstone Run, on the property of Jasper Culp, a surface exposure of fine quality clay was seen. The section taken follows:

	Ft.	In.
Flint clay and covered, *Sciotoville*	5	--
Shale and covered	37	--
Coal blossom, *Sharon*, seen across hollow.		
Conglomerate, *Sharon*	64	--

South of White Gravel Church, in Section 11, on land of Francis Warren, the following members are represented:

	Ft.	In.
Coal, *Anthony*	1	3
Clay, dark, plastic, *Sciotoville*	3	--
Covered	16	--
Shale	2	--
Ore, *Sharon*	--	10
Covered	8	--
Sandstone	2	--
Coal blossom, *Sharon*, reported thickness for coal and partings	3	--
Covered	5	--
Conglomerate, *Sharon*	65	--
Covered	5	--
Shale	2	--
Conglomerate	1	--

Across the hollow west of the above, flint clay was noted on the Sciotoville clay horizon. In Section 10, on the property of William Lyons, the following section was measured:

	Ft.	In.
Coal, *Anthony*	1	6
Clay, plastic, *Sciotoville*	3	--

In Section 5, on the Charles Pfleger farm, a good exposure of the Sciotoville clay was seen. A section taken in a deep ravine follows:

		Ft.	In.
Clay, flint, good	*Sciotoville*	2	8
Clay, light, plastic		1	--
Covered		20	--
Conglomerate, *Sharon*		52	--
Disconformity.			
Shale and sandstone, *Vinton*		30	--

In the same section, just north of the above, the clay is exposed on the hill north of George M. Fout's house. The strata recorded are as given below:

	Ft.	In.
Clay, flint, good, *Sciotoville*	4	--
Covered, barometric measurement	66	--
Shale	3	--
Coal blossom, *Sharon* or *No. 1*	--	6
Clay, plastic, bluish	2	--

The flint clay is reported also east of the above on the Elizabeth Crabtree property.

Owing to the ease of weathering, the Sciotoville clay is found on the outcrop only under favorable conditions; hence the limits of the deposits from surface indications alone cannot be well defined. The exposures in Madison Township indicate areas of some size. The deposits have good thickness, and the clay is of excellent quality. The region is well worth thorough testing.

Jefferson Township.—In Jefferson Township the Sciotoville clays occur at elevations from about 1,050 to 1,100 feet above sea, which thus restricts the areas to isolated knobs on the main ridges. In the southern part of the township the clay has been mined on two knobs in Section 10. On land of Charles B. Gillen the clay is of excellent quality, and the stratum lies close to the Logan shales. Flint clay of good quality was also noted on the high hill on the land of R. B. Grimshaw, in Section 27. This deposit was mined at one time for the fire brick yards at Portsmouth. In the northern part of Section 26, on the land of Benjamin Grimshaw, the outcrop of the clay was also noticed. Exposures of Sciotoville clay were noted in Section 22, on lands of Joseph R. Keller and Marion Ward. The section exposed along the road at this place is as follows:

	Ft.	In.
Coal blossom, *Anthony*	--	6
Clay and clay shale	9	6
Clay, flint, good, *Sciotoville*	1	3
Sandstone, shaly, ferruginous	--	6
Sandstone, clay-bond, light, soft	1	3
Sandstone	1	--
Shale, sandy	7	--
Sandstone, shaly, light	20	--
Sandstone, massive, parts covered	13	--
Covered	8	--
Clay, with coal bands, dark, *Sharon* coal horizon	4	--
Covered	30	--
Shale and sandstone, *Vinton*	20	--

East of the above exposure, on the Keller land, the flint clay is reported to be somewhat thicker, and was worked at one time. On Ward's land a light plastic and a few feet of "pink eye" clay were seen below the flint. Near Diffen Hill, in Section 11, the Sciotoville clay occurs on the land of Lima Conkle and along the township road. A section taken at this place is as follows:

	Ft.	In.
Clay, *Sciotoville*, upper part flinty, lower part sandy and ferruginous	4	--
Shale and covered	20	--
Sandstone, *Sharon*	10	--

In Section 3, on the land of D. McLaughlire, the member is made up of "pink eye," with a few inches of flint clay. The deposit is 17 feet above the Logan sandstone. The Sciotoville clay was not seen in Valley Township.

Bloom Township.—The deposits of Sciotoville clay in the western part of Blocm Township furnish the main supply of high-grade clays used by the fire brick plants now in operation in Scioto County. One of the important regions is near Gephart, where the Scioto Fire Brick Company and the Harbison-Walker Refractories Company have mined this clay for a number of years. The Pyro Clay Products Company of Oak Hill has also recently opened a shaft mine here. In sections 30 and 31, Bloom Township, the member has good thickness and volume, and has been worked for a number of years. F. M. Colgrove reports the clay on his property, where tested, to be 4 feet in thickness. Sections taken under heavy cover in the Herman Heldt mine, operated by the Scioto Fire Brick Company, are given in order to show the variability and character of the member. Section in the main entry:

		Ft.	In.
Coal, *Anthony*		--	9
Clay, flint, good	*Sciotoville*	1	4
Clay, semi-flint, good		3	--

Section at head of main entry:

		Ft.	In.
Coal, *Anthony*		--	1
Clay, flint, good	*Sciotoville*	2	4
Sandstone, with clay partings		2	1
Clay, somewhat siliceous		3	6
Sandstone, light, clay-bond		2	--

Section in a room:

		Ft.	In.
Clay, plastic		--	4
Coal, *Anthony*		--	7
Clay, flint, good	*Sciotoville*	1	5
Sandstone, clay-bond		1	--
Clay, semi-flint, good		2	6
Clay, siliceous, ferruginous		1	6

Another section in a room:

		Ft.	In.
Coal, *Anthony*, thickness irregular		--	4
Clay, flint, good	*Sciotoville*	1	6
Clay, semi-flint, good		3	--
Sandstone, light, clay-bond, irregular		1	10
Clay, flint, siliceous		1	8
Sandstone, light, upper surface irregular.			

Another important operation in the Gephart district is that of the Cook mine of the Harbison-Walker Refractories Company, in which the Sciotoville clay has excellent volume, but is somewhat variable in structure and character, as the proportions of flint and semi-flint clays change from place to place in the mine. In order to show these changes, and to show what may be expected in mining this bed, records taken at various places in the mine are given below.

Section in room with 90 feet of cover:

	Ft.	In.
Shale, blue	20	--
Coal, *Anthony*	--	$\frac{1}{2}$

		Ft.	In.
Clay, flint, good	*Sciotoville*	1	1
Clay, plastic, good		1	9
Clay, semi-flint, good		4	--
Sandstone, light, clay-bond.			

Section in room with heavy cover:

		Ft.	In.
Coal, wanting.			
Clay, flint	*Sciotoville*	1	4
Clay, plastic		1	6
Clay, semi-flint		3	--
Clay, "pink eye"		2	--

Section in room:

		Ft.	In.
Coal, *Anthony*		--	½
Clay, flint	*Sciotoville*	1	8
Clay, plastic		1	8
Clay, semi-flint		2	--
Clay, flint		3	--
Sandstone, light, clay-bond.			

Section in room:

		Ft.	In.
Coal, *Anthony*		--	½
Clay, flint	*Sciotoville*	1	9
Clay, plastic		--	10
Clay, semi-flint		1	6
Clay, flint		4	--
Sandstone, light, clay-bond.			

From this district, also, the Pyro Clay Products Company of Oak Hill obtains its supply of clay, which is taken from a shaft mine about 80 feet in depth. The area was thoroughly prospected by the drill, and the quantity of clay available is amply sufficient to last for many years. The average of the drill records shows that the usual thickness of the deposit, which is made up of flint and semi-flint clays, is from 5 to 8 feet. Further analyses of the clay cores from the drill show that the material is of the highest grade. The clay along the main entry, which at present has not been driven far, is largely flint, and is about 5 feet in thickness.

Another center of mining at present is on Frederick Creek at Scioto Furnace and at Edmunds. The clay is usually of excellent quality, and the bed has a good mean thickness. The deposits are made up of flint, semi-flint, and "pink eye" clays, with, in places, a white, fine-grained sandstone or ganister. There is no bedding plane between the flint and semi-flint, the semi-flint and the "pink eye," or flint and "pink eye." Also there is no regularity of order in which the beds were laid down. Often the flint lies directly on the "pink eye," although the usual arrangement in descending order is flint clay, semi-flint, and "pink eye." In some places the flint clay is wanting, while the same is true elsewhere of the semi-flint and "pink eye." The white, fine-grained sandstone or ganister is usually local. On the following tables are given sections taken in the mines of the Buckeye Fire Brick & Clay Company and the Harbison-Walker Refractories Company. These were taken at regular intervals in order to show the variation in the deposition of the different layers. The full thickness of the "pink eye" was not obtained, as the floors of the mines are in this material; hence the unknown thickness below is indicated by an x. See Table IV.

A drill record made on the land of W. E. Ranchous and others in Section 16, and given below, shows that the Sciotoville member has excellent volume in this locality:

		Ft.	In.
Black slate	(*Quakertown*)	--	6
Coal		--	6
Clay mixture		8	--
Black slate		1	--
Slaty sandstone		5	6
Sandy slate		3	--
Slate		26	6
Bone coal, (*Anthony*)		--	4

Terms in parentheses supplied by the writer.

On Skull Creek, in sections 8 and 9, the Sciotoville clay was formerly worked along the outcrop. A section at the mouth of an old mine is as given below:

		Ft.	In.
Shale		4	--
Clay, flint	*Sciotoville*	3	6
Clay, "pink eye," seen		3	--

On Laurel Lick Run, north of Pinkerman, this bed has been opened in a number of places in sections 5 and 8, where, on the farm of Lemm Cadot, the following record was obtained:

		Ft.	In.
Clay, flint, somewhat siliceous	*Sciotoville*	3	--
Clay, reported below		4	--
Covered		31	--
Sandstone	*Sharon*	8	--
Covered		6	--
Sandstone, massive		27	--

On Bear Run, near the Baptist Church, in Section 5, about 3 feet of flint clay with soft clays below were exposed, but no good section was obtained. A record taken on the land of William Tripp (Kinker farm), in Section 4, and given below, shows the structure of the Sciotoville clay and its relations to other important members:

	Ft.	In.
Coal blossom, *Bear Run*	--	6
Clay shales, dark	3	6
Shales, gray, with parts covered	28	--
Sandstone, thin and medium bedded	13	--

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western part of Bloom Township. The Scioto Fire Brick Company at Sciotoville, and the Pyro Clay Products Company at Oak Hill, draw their supply from mines near Gephart Station, on the Baltimore & Ohio Southwestern Railroad. The Buckeye Fire Brick & Clay Company at Scioto Furnace mines its clay near the plant. The Portsmouth and Star works of the Harbison-Walker Refractories Company obtain their supply at present from mines at Gephart, and near Edmunds on Frederick Creek. Small quantities of clay are also shipped from the Scioto Furnace region to Oak Hill. The Pinkerman and Bear Run fields are not being worked at present, but they may be drawn upon in the near future, as William Tripp, who largely controls these fields, contemplates the erection of a plant at South Webster at an early date. The area of the known unworked fields in Bloom Township is large, and as the clay deposits are heavy, the quantity of material available is amply sufficient to supply the various yards for many years.

Method of Mining

Along the outcrop and under shallow cover, the clay is mined by stripping or benching. The overburden is removed until the shales or sandstones above become solid enough to form a roof, when the usual method of drift mining is practiced. In most cases the single entry system, with cross entries, from which the rooms are turned, is used. The main headings are usually from 8 to 12 feet wide, while the cross entries are a foot or two narrower. The rooms usually turned from 30 to 40 feet apart along the cross entries are worked from 20 to 30 feet wide and from 100 to 250 feet long. The entries are held by posts and caps. At the entrance of the mine lagging is also used. In the rooms the number of posts used and the manner of spacing them depend on the character of the roof, which in most cases is tough shale or sandstone; hence it is easily held. The usual method of draining is by ditches, or by hand pumps with siphon. Steam pumps are seldom used. The method in common practice of furnishing air in the mines is by air shafts with furnaces. The circulation in the rooms is by break-throughs and brattices. The clay is shot off the solid in both entries and rooms. The holes are usually drilled by hand augers, as the clay cuts easily, and the shooting is done with fuse, or squib and black powder. In the small mines the clay is hauled by hand, but in the larger mines it is removed by mule power. At present the larger mines are operated in a systematic manner and with fair economy.

Character of Clays

The materials found on the Sciotoville horizon are flint, semi-flint, plastic, and "pink eye" clays, with ganister or clay-bond sandstone. Clay is a hydrated aluminum silicate, the best varieties of which have a composition approaching closely that of kaolinite, which is $Al_2O_3 2SiO_2.2H_2O$. The composition of the flint, semi-flint, and plastic clays is practically the same, while that of "pink eye" contains in addition to the clay components several per cent of iron oxides. These different types of clay differ greatly in their physical properties.

Flint clay is a hard, dense, homogeneous substance, breaking with a conchoidal fracture in any direction, and ordinarily showing no trace of bedding planes. On weathering the Sciotoville flint clay breaks down to small cubical masses, but, however complete the disintegration, the particles always remain sharp and gritty and have no apparent plasticity. The color, depending mainly on the amount of carbonaceous matter present, varies from a light gray to a dark gray, or to nearly black. If iron compounds are present in considerable quantities the colors imparted by these pigments are reds, pinks, or greens. The distinguishing feature of flint clay is its flinty, non-plastic nature.

The semi-flint clay is hard, dense, homogeneous, and breaks as the flint clay does. It shows no distinct bedding planes, but always slickensides. The clay breaks down on weathering with the development of some plasticity. The colors are similar to those of the flint clays. Semi-flints often graduate into the flint clays. The identification points are the flinty nature of the clay with the presence of slickensides or pressure slips, and with the development of a limited plasticity on weathering or by protracted working.

The plastic clay is soft, compact, and homogeneous, and has no bedding planes, but is usually marked in all directions by slickensides. On weathering, or simply working it with water, the plastic properties are highly developed. In color it varies the same as the flint and semi-flint. It is characterized by its soft nature and great plasticity.

"Pink eye" is a plastic clay carrying a notable quantity of iron oxide, which is in a very finely divided state, and is segregated somewhat, thus giving the clay a blotchy or mottled appearance.

The ganister found on this horizon is a sandstone composed of light, fine-grained quartz sand, with clay for the bonding material. Usually it is quite free from fluxing impurities, but in a few places noted it was charged with iron oxide, and resembled a "pink eye" clay in color.

Composition

The composition of the Sciotoville clays approaches closely that of kaolinite, which is:

Silica, SiO_2	46.3
Alumina, Al_2O_3	39.8
Water comb., H_2O	13.9
This dehydrated gives:	
Silica, SiO_2	53.77
Alumina, Al_2O_3	46.23
Theoretical ratio, $\frac{SiO_2}{Al_2O_3}$ =	1.16

The analysis of the calcined flint clay from Scioto Furnace is:

Silica, SiO_2	54.40
Alumina, Al_2O_3	41.19
Ferrous oxide, FeO	1.35
Lime, CaO	.08
Magnesia, MgO	.32
Manganous oxide, MnO	.01
Potassium oxide, K_2O	.23
Sodium oxide, Na_2O	.13
Sulphur trioxide, SO_3	trace
Phosphoric acid, P_2O_5	.11
Titanic oxide, TiO_2	1.82
	99.64
Ratio, $\frac{SiO_2}{Al_2O_3}$ =	1.32
Acid fluxes	1.93
Basic fluxes	2.12
Total fluxes	4.05
Heat test, cone 34 or 3,290° F.	

This compares favorably with the analyses of some of the most noted clays in the United States, which are given below:[1]

	No. 1	No. 2	No. 3
Silica, SiO_2	53.65	51.87	54.20
Alumina, Al_2O_3	42.31	43.21	40.65
Ferrous oxide, FeO	.69	1.86	1.70
Lime, CaO	.27	.42	.45
Magnesia, MgO	.26	.35	.23
Potassium oxide, K_2O	.87	.31	.34
Sodium oxide, Na_2O	.62	.19	.18
Phosphoric acid, P_2O_5	trace	.04	.03
Titanic oxide, TiO_2	1.46	1.86	2.10
	100.13	100.11	99.88
Ratio, $\frac{SiO_2}{Al_2O_3}$ =	1.27	1.20	1.33
	No. 1	No. 2	No.
Acid fluxes	1.46	1.90	2.13
Basic fluxes	2.71	3.13	2.90
Total fluxes	4.17	5.03	5.03
Heat test, cone	34–35	33–34	34–35
Temperature, degrees F.	3,290–3,326	3,254–3,290	3,290–3,326

No. 1. Mercer clay from Clarion County, Pennsylvania. Glass house, blast, and steel furnace refractory ware.

No. 2. Brookville clay from Clearfield District, Pennsylvania. Blast and steel furnace refractory ware.

No. 3. Sciotoville clay from Olive Hill, Kentucky. Blast and steel furnace refractory ware.

The Sciotoville clays always contain appreciable amounts of other ingredients, some of which are especially detrimental to the ware required to withstand high heat strains. These impurities amount to

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[1] See Table V.

TABLE V

15	16	17	18	19	20
43.48	43.62	42.40	40.52	44.80	48.87
39.14	37.96	37.97	26.48	35.00	32.39
1.14	1.81	2.20	15.66	--------	--------
------	--------	--------	--------	1.22	1.26
------	1.51	1.73	1.31	1.70	1.45
.60	.44	.49	.42	.59	.40
.25	.66	.94	.90	none.	.35
------	.29	.41	.27		
				1.56	1.52
------	.51	.46	1.66		
------	.019	.029	.028	.099	.12
------	.108	.071	.090	.39	.26
15.18	13.60	13.45	12.55	15.15	12.98
------	--------	--------	--------	--------	--------
------	trace.	.34	.10	--------	--------
99.79	100.527	100.49	99.988	100.509	99.60
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ıell University. Trans. American

Furnished by Scioto Fire Brick

ɑ Refractories Co.
ted by William Tripp.
ıon-Walker Refractories Co.
Iarbison-Walker Refractories Co.
l by Harbison-Walker Refracto-

ıe Pyro Clay Products Co. Anal-

he Pyro Clay Products Co. Anal-

several per cent even in the purest natural clays. The quality of a clay depends primarily on the kinds and on the quantities of the deleterious materials present.

Sand or free silica is the most common and least objectionable impurity found in clays. The quantity varies from a trace in the pure clays to that found in the ganisters, which have a few per cent of clay for the bonding material. The fusion curve shows that for any mixture of the components, clay and sand, the melting point is lower than for that of either component alone. The melting point of clay is 1,830° C., of quartz about 1,600° C.,[1] while that of the eutectic mixtures is slightly below 1,600° C.; hence free quartz in a clay always lowers the fusion point, but to no great extent in any case. When the effect of slag on clay ware is considered then free silica or sand in the clay may be detrimental or beneficial, depending largely on the composition of the slag. The acidity of the brick should approach closely that of the slag. Pure clay is considered neutral. For example, the mineral components of basic blast furnace slag are mainly $2CaO.SiO_2$, $2CaO.Al_2O_3.SiO_2$, and small amounts of $CaO.Al_2O_3.2SiO_2$. But little combination is possible between these and pure clay, $Al_2O_3.2SiO_2$, consequently only a slight solvent action is exerted. The influence of the above slag on a brick made from a clay containing a considerable amount of quartz sand is much different. In this case the slag components react with the clay, $Al_2O_3.2SiO_2$, and free silica SiO_2, to form the more acid minerals, $CaO.SiO_2$ and $CaO.Al_2O_3.2SiO_2$. In this case the siliceous brick would be taken into solution easily and go out with the slag. If the slag is decidedly acid, like the old charcoal furnace slags which were made up of $SiO_2.CaOSiO_2$ and $CaO.Al_2O_3.2SiO_2$, then brick with free quartz sand will be but little affected, and under such conditions should give good service. The acidity of the slag to which the brick are subjected should be the guide for the amount of free silica allowable in the ware.

Where brick are subjected to differential heats the rapid expansion of the free silica is important, for this volume change soon causes brick with a high silica content to become fragile, crack, and finally to break into pieces; consequently free silica in large amounts should be avoided in ware where extreme changes of temperature are necessary.

Iron compounds are always present in clays. The quantity varies from about 1 per cent in the purest types to 15 or 20 per cent in "pink eye". The forms in which it occurs are pyrite, FeS_2, siderite, $FeCO_3$, hematite, Fe_2O_3, and limonite, $2Fe_2O_3.3H_2O$. During the burning of the ware the FeS_2 usually changes to the oxide, but under some conditions it is reduced only to FeS, which fuses at a low temperature. The other minerals go to Fe_2O_3, or FeO, depending upon the condition of the flame. There is no combination between ferric oxide, Fe_2O_3, and clay. In fact, it is a good refractory material when under oxidizing conditions, and consequently is not detrimental to ware so subjected. "Pink eye" clay may be used with good results for ware where oxidizing conditions are maintained. Ferrous oxide, FeO, forms two definite low fusing compounds with silica, which are fayalite, $2FeO.SiO_2$, and grunerite, $FeO.SiO_2$. Ferric oxide is easily reduced to the lower form, ferrous oxide, by the action of carbon monoxide of the kiln gases, which compound is produced by an insufficient air supply.

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[1] Preliminary report on the Ternary System $CaO-Al_2O_3-SiO_2$ by E. S. Shepherd and G. A. Rankin, Carnegie Institute of Washington, Dec., 1910.

$$Fe_2O_3 + CO = 2FeO + CO_2.$$

The ferrous oxide then attacks the silica to form the silicates.

$$FeO + SiO_2 = FeO.SiO_2, \text{ grunerite.}$$
$$2FeO + SiO_2 = 2FeO.SiO_2, \text{ fayalite.}$$

Both of these minerals are black, and by fusing at low temperatures they readily produce the black blotches and fused masses seen on fire brick, which, if burned with a free draft, will not show this defect. Clays high in fossil organic matter and iron oxides give dark cores or reduced zones in the brick if not properly treated during the oxidation period of burning. In ware from high-grade clays the structure is sufficiently open to allow complete oxidation, so but little trouble is experienced in the reduction of the iron oxides by carbon. In ware with a high percentage of plastic clay this effect is liable to result, so if reduction takes place, it should be burned with a free draft, and the kiln held at a low red heat until the black core in the brick has disappeared before completing the burn.

Titanic acid is always present in clays in quantities varying from 0.5 to 4 per cent, but averaging about 1.5 per cent. In small amounts it acts as a flux, but is not very effective. Tests run by various investigators show that 5 per cent lowers the final fusion point about 30° C. but promotes vitrification much earlier. Lime and magnesia, always present in clays in various amounts, are active fluxes. They form direct compounds with silica and alumina, the fusion points of which are from 1,200 to 1,500° C., but the eutectic mixtures of which melt at much lower temperatures. In clays the fluxing action of lime and magnesia begins at about 700° C. when incipient fusion is apparent. Experiments made by several authorities show that 5 per cent lime lowers the final fusion point about 40° C., while 5 per cent magnesia lowers it about 60° C. In either case the vitrification point is lowered far below that of final fusion, and the vitrification in many industrial operations is the limit of value of the ware.

The alkalies or oxides of sodium and potassium are the most active fluxes found in clays. Their fluxing action begins at low red heat, and it soon reaches completion, as silicates and aluminates are readily formed. Their fluxing action is about twice as great as that of lime or magnesia. In all ware subjected to severe heat strains these components must be kept low. The quantity of the alkalies found in the Sciotoville clay seldom exceeds one per cent, and is usually much less than this. Phosphorus pentoxide is an acid flux, but the quantity usually present in the Sciotoville clay is too low to exert any marked influence, as it is seldom over .10 per cent. Manganese oxide, a basic flux, is occasionally found in small quantities, especially if the iron oxide in the clay is high. Its influence is about the same as that of ferrous oxide. The formation of a eutectic from these various eutectics is also a factor in the further lowering of both the initial and final fusion points.

In determining the refractoriness of clay ware there is no fast rule fixing the amount of the various fluxes present, for often ware with a moderate amount of fluxes gives high heat tests, while another sample, with a small amount of fluxes, goes down much below the temperature expected. It depends on the amount and kind present, and on the manner of distribution. For a given kind of flux the refractoriness agrees in general with the quantity present, and with its state of distribution. Two per cent of ferrous oxide, finely divided and evenly distributed, is more detrimental than the same amounts in lumpy particles. For different fluxes it depends on the activity of each. As an example, 2 per cent of alkalies exert far more action than the same amount of ferrous oxide.

In general, for the highest grades of refractory ware the total fluxes should not exceed 5 per cent, and for medium grades it should not exceed 9 per cent. A few per cent of fluxes, when combined with the clay components, produce relatively large amounts of the low fusing compounds. This is shown in the following, which illustrates some of the possible reactions that may take place:

2 per cent FeO+1.67 per cent SiO_2 form 3.67 per cent $FeO.SiO_2$, grunerite.
2 per cent CaO+2.14 per cent SiO_2 form 4.14 per cent $CaO.SiO_2$, wollastonite.
2 per cent MgO+3.00 per cent SiO_2 form 5.00 per cent $MgO.SiO_2$, enstatite.
2 per cent Na_2O+1.92 per cent SiO_2 form 3.93 per cent $Na_2O.SiO_2$, sodium silicate.
2 per cent K_2O+1.28 per cent SiO_2 form 3.28 per cent $K_2O.SiO_2$, potassium silicate.
2 per cent Na_2O+14.90 per cent $Al_2O_3.6SiO_2$ form 16.90 per cent $Na_2O.Al_2O_3.6SiO_2$, albite.
2 per cent CaO+7.93 per cent $Al_2O_3.2SiO_2$ form 9.93 per cent $CaO.Al_2O_3.2SiO_2$, anorthite.

Five per cent of the fluxes usually found in clays will thus form about 10 per cent of low fusing compounds; hence for all ware subjected to high heats it is necessary to keep the total fluxes low.

A plastic clay vitrifies and softens at a much lower temperature than a flint clay, although the final fusion point of both may be the same. In this respect a semi-flint clay is about midway between the plastic and flint. So where vitrification of the ware is undesirable, or where it is subjected to a high heat with a heavy load, the quantity of plastic clay in the batch should be kept low. A good example of this may be seen in the lower part of a blast furnace stove, where the strains both from heat and from load are moderately high, and where the changes in temperature are sudden. If the brick vitrify they soon spall, and their heat absorbing capacity is lessened. Any softening with the load carried causes deformation of the checkers, etc., with suspension of the blast heating operation. Consequently, the clays used in the manufacture should be selected with reference to the conditions and strains involved. Under severe treatment the superiority of flint clays over plastic clays is beyond question, as this point has been definitely proved by the iron and steel producers.

The behavior of fire brick under load conditions has been studied by Bleininger and Brown, and the following discussion is taken from their article on this subject:

> As to fire bricks made from a clay material which is sufficiently plastic as to be used alone, it is clear that its ability to carry loads depends simply upon its composition. Some of the very best tests have been obtained from materials of this kind. This case is the simplest and needs no particular attention, since a clay will stand up or fail by virtue of its own quality. A pure clay of moderate plasticity would be the ideal material for the manufacture of fire brick. Since, however, such clays are usually not available, the question of judging them as to their composition deserves some attention from the standpoint of their load carrying capacity. From this point of view the most important consideration is that of the amount of fluxes.
>
> At the high temperature involved, the presence of even a small amount of fluxes becomes a potent factor and hence it is far better to select a clay higher in silica and low in fluxes than a clay possessing the silica-alumina ratio of kaolin but higher in fluxes. The effect of silica in lowering the refractoriness of clays is commonly exaggerated as far as practical results are concerned, and it is usually not necessary to reject a clay on this account. However, high silica and high fluxes make a dangerous combination. From this it follows that a clay fairly high in fluxes, corresponding for instance to $0.22\ RO.Al_2O_3.2SiO_2$, would be improved by the dilution with a siliceous material low in fluxes, or even by the addition of a clear sandstone, the principal requirements being intimate blending and grinding.
>
> In regard to the fluxes present in a clay, the state and size of grain of the iron is of importance, for it is evident that coarser grains of iron minerals will do no harm, although in the analysis they contribute their share towards raising the amount of fluxes.
>
> The fluxes are an important factor in the ability of refractories to carry loads, in-as-much as they become active at low temperatures by forming easily fusible silicates. As the temperature rises, increasing amounts of silica and alumina are dissolved, and it becomes, therefore, simply a matter of the amount of this fused matter and its viscosity, whether or not a given refractory will stand up at the temperature in question.
>
> By grinding the clay as coarse as possible, conditions are improved, as in doing this the formation temperature of the fusible silicates is raised, since the process of solution is hindered, and by this means it may be possible to bring the product out of the danger zone. In time, however, equilibrium conditions are approached closer and closer, so that finally the brick may fail under the same conditions under which they stood up at first.
>
> In bricks made from flint and bond clay we are dealing with comparatively

coarse grains of flint and fine grains of bond clay. These two materials are mixed and blended as far as the processes customary at the present time permit it. The bond clay breaks up more readily, and the plastic mass produced by it cements together the grains of flint clay and calcine. Assuming that the flint clay is of good quality, the load carrying capacity of the product depends upon the bond, as has been shown above. It is evident that if the flint clay is inferior the product suffers accordingly. These two materials may be considered from the standpoints of chemical composition, vitrification range, and fineness of grain.

Flint clay, the geological origin of which is still in dispute, is deficient in plasticity, although by very fine grinding it may become sufficiently plastic to be molded. Its refractoriness, when pure, is very high. A brick made from flint clay (by fine and long continued grinding) is able to carry high loads. As far as refractoriness is concerned, it is good practice to grind it quite coarsely for reasons already indicated. The fact that occasionally it is in part calcined does not affect its refractory behavior but simply corrects the shrinkage suffered in burning.

In plastic bond clays a good grade of plasticity is desirable, although this is not important, where their refractoriness is high. In clays of greater fusibility, high plasticity enables the manufacturer to cut down its amount to a minimum. In the selection of a bond clay, it is evident that its vitrification range should be as long as possible, i. e., the temperature at which it becomes dense and non-absorbent should be as high as possible.[1]

Weathering improves the quality of the Sciotoville clay. The lumps break down by subdivision into small particles, the size of which depends on the time of exposure. Weathering develops practically no plasticity in the flint clay, although it may be disintegrated to a fine powder which acts in much the same way as fine sand. With semi-flint clay, however, a limited plasticity is developed when the mass is broken down to a fine state of division by long exposure. Weathering develops the maximum plasticity or bonding power in the plastic clay, as one of the important factors in producing plasticity is fineness of grain which is thus greatly increased by exposure to the elements. From this point of view weathering is beneficial.

But little work has been done in determining the amounts of impurities carried away by a process of weathering. Some of the reactions due to weathering produce soluble compounds. Pyrite and marcasite oxidize to the soluble sulphate, with also the formation of secondary soluble compounds, much resembling the alums; thus both iron and sulphur as soluble salts are partially eliminated. Lime and magnesia are generally present in the form of carbonates, which compounds are changed to the soluble bicarbonate by the action of carbon dioxide gas, held in solution in rain water, and in the moisture of the atmosphere. Some of the iron in the clay also exists as the carbonate which is similarly affected by this acid water. Some alkalies are lost by direct solution, and by their uniting with other elements to form soluble compounds. The salts found on weathered lumps of clay invariably show some of these bases to be present. By a thorough process of weathering and leaching some considerable proportion of the impurities may thus be eliminated. The process would increase the cost of the product, but would be justifiable in the manufacture of the highest grades of ware.

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[1] A. V. Bleininger and G. H. Brown. Trans. American Ceramic Society, Vol. XII, pp. 360-363.

Process of Manufacture

The materials available are the four types of clays, flint, semi-flint, plastic, and "pink eye." Calcine is used in some grades of ware to decrease the shrinkage, and to produce a better structure. That used may be either flint and semi-flint clays, burned for the purpose, or bats and refuse brick which have been burned. For the highest grades of ware, well weathered flint and semi-flint clays, with at times some calcine, or these with a small amount of plastic clay, compose the mix. Plastic clay is less refractory and vitrifies earlier than the flint or semi-flint; hence it should be kept low where the ware is required to withstand severe heat strains. "Pink eye" clay is used in low-grade ware, and that subjected only to oxidizing conditions. The quantity of each clay in the batch should be proportioned according to the desired chemical and physical qualities of the ware, such as silica-alumina ratio, solubility, strength, density, vitrification, and final fusion points.

The practice for years was wet pan grinding and tempering exclusively, which develops the maximum plasticity and produces good interlocking of the various sized grains. At present dry pan grinding is practiced to a considerable extent. The tempering is then done in a wet pan or pug mill. The same bonding power with a less amount of plastic clay is obtained by the wet pan process, which develops even a fair plasticity in a semi-flint clay. With this practice the plastic clay, which is the weak part of high-grade refractory ware, may be kept low.

The shaping of the ware is done by hand molding, or by machines of the auger and plunger types. Hand molding produces a ware with a more open structure and with less strain defects than that produced by the machines. Where density is desired, machine-made ware is the best. Ware made by auger machines has a greater density than that made by plunger machines, but is more subject to laminations and cracks, and in general the latter kind is favored over the former. Large and oddly designed shapes are all hand molded.

The old method of drying the ware on floors heated by hot air or by steam is the general practice today, although some plants use tunnel driers for drying machine-made brick. The rate of drying should be such that the entire brick has much the same consistency throughout. If the floors are too hot when the outside of the brick is at the right temper the inside is too soft, and if the ware is pressed with this wet core, strains are produced on further drying, which later may develop into cracks. Brick should be pressed when the temper is tough and leathery, for then the maximum amount of condensing is produced, and the ware is in the best condition for handling.

But little difficulty is experienced in the burning of fire brick compared, for example, to that of burning paving brick or sewer pipe. The ware is porous, consequently the combined water is easily expelled, and the oxidation of carbon and oxides is rapidly promoted. Both coal and gas are used for fuel. Coal-fired brick generally have the best structure, which is produced by the annealing effect caused by the method of firing. At every "baiting" of the fire a short reduction period is induced, followed by a longer period of oxidation and by fluctuations in the temperature, which causes a firmer setting of grains by the bonding components. In firing with gas the condition of the flame is usually oxidizing throughout the whole interval, and the temperature is rising gradually. The ware is generally somewhat "punky", but lighter in color, as the iron is not reduced. All high-grade refractory ware should be burned at not less than cone 11, 2,462° F., as at this temperature the final water shrinkage is practically gone.

Fire brick should be tested for those strains which the brick are required to withstand in the industrial operations in which they are to be used. The more important of these follow:

1. Where the brick are subjected to the action of slag, the acidity of both brick and slag should be considered. Chemical analyses give the desired information.

2. Where high heats are employed, the temperature and also the condition of the flame, whether oxidizing or reducing, must be considered and the tests on the brick run accordingly. Some components acting as fluxes under reducing conditions are very refractory when the flame is strictly oxidizing. Gas, electric, and Deville furnaces are employed for this test.

3. The crushing strength of brick at high temperature, and under heavy load, is important in many metallurgical operations. The method of testing is that worked out by Bleininger and Brown.[1]

4. Fire brick are often required to withstand severe abrasion. A modified paving brick rattler test on cold brick gives a fair idea of their quality, but the best tests are obtained if the brick are rattled at approximately the temperature carried in the industrial operation.

5. The sudden, severe changes of temperature on fire brick, for example, in blast furnace stoves, cause early failure by checking and cracking. The tests for differential heat treatment are easily carried out by repeated heating in a kiln and then by cooling quickly in air or water.

6. The slagging or corrosive action of gases on fire brick is usually caused by some acid or fluxing component contained in them. These

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[1] The behavior of fire brick under load conditions at a temperature of 1,300°C., Trans. American Ceramic Society, Vol. XII, pp. 337-369.

gas components should be determined, and then tests run accordingly. Where coal is used as fuel, the sulphur contained produces acid radicals which attract the brick. In this case a good test is obtained by the action of weak sulphuric acid on the ware.

7. The heating, absorbing, or thermal capacity of brick is a very important property in ware for regenerators. But little work has been done along this line on refractory ware, but the common methods of determining specific heats of solids are readily applicable.

8. The conductivity of refractory materials is also an important quality in brick for many uses. Very satisfactory methods have been devised for this.[1]

In determining the quality of fire brick for any particular purpose the testing should be thorough, and should conform to the strains and conditions existing in use. A heat test tells but little in regard to the action of slags or to the effect of sudden changes of temperature. Many brick are unjustly condemned from improper and careless testing.

Economic Value

The Sciotoville clay is the basis of the fire brick industry in Scioto County, which began at Sciotoville in 1864, and which at present is one of the leading industries based on natural resources. The clays are used for the manufacture of refractory clay ware for blast furnaces, steel furnaces, stoves, regenerators, soaking pits, annealing ovens, ladle linings, cupolas, coke ovens, glass houses, fire boxes, cement kilns, lime kilns, and for other operations where the ware is subjected to high temperatures. In Scioto County, at present, three firms are manufacturing fire brick as follows:

The Scioto Fire Brick Co., Sciotoville.
The Buckeye Fire Brick and Clay Co., Scioto Furnace.
The Harbison-Walker Refractories Co., Portsmouth.

The latter company operates two plants, the Portsmouth works, located in the east end of Portsmouth, and the Star works, located on the Ohio River one mile west of Sciotoville.

The Pyro Clay Products Company of Oak Hill, Jackson County, obtains its supply of flint clay from a mine located near Gephart Station; hence this plant really belongs in the Sciotoville clay district, and will be treated accordingly. Mr. A. M. Turner, general manager and treasurer of the Scioto Fire Brick Co., reports as follows:

> The plant is located on the Ohio River at Sciotoville. The company was incorporated in 1871 under its present title, and was a consolidation of three companies, McConnell, Porter & Co., established in 1864; Taylor, McConnell & Co., established

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[1] Conductivity, Porosity and Gas Permeability of Refractory Materials by S. Wologdine and A. L. Tuceau. Electrochemical and Metallurgical Industry, Vol. VII, No. 9, Sept., 1909, p. 383.

in 1865; and the Salamander Fire Brick Co., established in 1868. This consolidation made it at that time the largest fire brick company in the country.

The company owns or controls under long time leases, 2,500 acres of the best clay deposits in southern Ohio, which are located north of Sciotoville, and near Gephart Station on the Baltimore and Ohio Southwestern Railroad. These deposits are made up of flint, semi-flint, and, in places, plastic clays of great purity. The method of mining the clays at present is by drifting, but formerly benching was also practiced.

The plant equipment is as follows: The buildings made of brick for housing the power plant machine room, and drying floors, are well arranged and substantially built. The power is furnished by a 100-H.P. boiler and a 50-H.P. engine. The machines for grinding the clay are two wet pans and one dry pan. The pressing is done on hand presses.

The dry floors are 100 x 100, and 45 x 85 feet, or they have a total drying surface of 13,825 square feet. The drying is done by waste heat from the kilns, which is forced through the floor tunnels by fans. The brick are burned in five 50,000 capacity each, down-draft kilns. The annual capacity is 3,500,000 brick, 9-inch equivalents. High-grade refractory ware is manufactured for use in blast furnaces, hot blast stoves, open hearth furnaces, soaking pits, coke ovens, cupolas, rolling mills, malleable iron works, glass works, cement kilns, steel furnaces, and boiler settings. Ground fire clay is also prepared for the market. The shipping facilities are the Norfolk and Western, the Baltimore and Ohio Southwestern railroads, and the Ohio River. The principal markets are the southern furnace territory and Ohio, Indiana, West Virginia, and Michigan.

A report on the plant of the Buckeye Fire Brick & Clay Co., furnished by E. P. Stevens, general manager and treasurer, follows:

The original company was organized in 1901, and reorganized under the present management in 1903. The plant is located at Scioto Furnace near the center of the clay field in eastern Scioto County. The company controls 583 acres of clay lands in this field. The deposit has good thickness, and the flint and semi-flint clays have a high degree of purity, comparing favorably with the best clays found in Pennsylvania and Kentucky. The composition of the flint and semi-flint clay in the deposit is very uniform; thus assuring standard quality at all times. The clays are mined entirely by drifting, as the overburden is heavy. The material is hauled to the yard by mule power on a tram road, then elevated on trestles by a 60-H.P. hoist engine and dumped in piles, where the clay is allowed to weather thoroughly before use.

The plant equipment which is well arranged for economy in the handling of material is as follows: The buildings constructed of wood are well supported and durable. The power is furnished by one 150-H.P. and one 80-H.P. boiler and a 240-H.P. engine. Three 8-foot wet pans, one 8-foot, and one 9-foot dry pan made by The Frey-Sheckler Company, are used in the grinding of the raw materials. The shaping of the ware is done by hand molding or by a Stevenson 22-inch cylinder, 150 pounds pressure sewer pipe press. The three drying floors constructed of concrete have the dimensions: 60 x 338 feet, 60 x 96 feet, and 60 x 84 feet, which give a total drying area of 31,080 square feet. A periodic tunnel drier, consisting of eight 90-foot tunnels with a capacity of 32,000 brick, 9-inch equivalents, is used for drying some grades of ware. Live steam from the boilers, exhaust steam from the engine, or waste heat from the kilns is used under the drying floors, while waste heat from the kilns only is used in the tunnel drier. The heating circulation is induced by two 8-foot fans operated by two 60-H.P. engines. The plant is lighted throughout by electricity. The ware is burned in down-draft, center-stack kilns at temperatures varying from 2,400 to 2,600° F. The 12 kilns, 26 feet in diameter inside, have a capacity of about 60,000 9-inch brick each. The annual capacity of the plant is 6,500,000 brick, 9-inch

equivalents. Lump and ground clays are also marketed. The average number of men employed at the plant and in the mines is 108. The company owns a hotel and 40 houses which are rented to the employees.

The company has been very successful in the manufacture of high-grade refractory ware, and the plant has been in continuous operation for over 11 years, and, with the exception of short periods, at full capacity. The company makes a specialty of the manufacture of intricate and special shapes. We make also all styles of standard shapes. We manufacture ware for the following classes of work; locomotive arches, blast furnaces, heating furnaces, puddling furnaces, melting furnaces, scrap furnaces, malleable furnaces, open hearth furnaces, coke ovens, gas producers, annealing furnaces, soaking pits, ladle linings, lime and brick kilns, cupolas, foundry work, boiler settings, stove linings, etc. The plant is located on the Baltimore and Ohio Southwestern Railroad, and the principal markets are west and south.

A report furnished by John Lowry of the Harbison-Walker Refractories Company concerning its works in Scioto County follows:

The Harbison-Walker Refractories Company operates 2 fire brick works, the Portsmouth plant at Portsmouth, and the Star plant about one mile west of Sciotoville, also a clay mill on Frederick Creek about two miles from South Webster.

The Portsmouth plant has at present a capacity of 40 M. high-grade fire clay brick per day. The plant was built originally by the Hocking Valley Fire Brick Company, of Logan, Ohio, of which W. Q. Adams, one of the best fire brick men of his day, was president, and Reuben Jenkins, vice-president. The original capacity was 12 M. per day. Shortly after construction, it was incorporated as The Portsmouth Fire Brick Company, with W. Q. Adams, president, Reuben Jenkins, vice-president, and L. C. Turley, secretary. Two years after construction the capacity was increased to 20 M. per day, and from this it was gradually increased to the present capacity.

The Star plant at present has a capacity of 25 M. per day. The plant was built in 1871 by McConnell-Towne and Company, and was known as Scioto Star Fire Brick Works. The original capacity was 8 M. per day, but in 1872 this was increased to 12 M. Later the plant was gradually increased to its present capacity.

Both the Portsmouth and Star works, in 1900, were merged with Kentucky Fire Brick Company, Webster Fire Brick Company, and Blast Furnace Fire Brick Company into the Portsmouth and Kentucky Fire Brick Company. One and one-half years later the Portsmouth and Kentucky Fire Brick Company was merged into the Harbison-Walker Refractories Company.

The equipment of the Portsmouth plant is as follows: The unloading of the clay from the cars is done from trestles which allow a large stock to be kept on hand for weathering. Four pans are used in the grinding of the clays which then go to the molders. The power used is from 2 slide-valve, and from 1 piston engine with a total of 200-H.P. The steam is generated in 3 horizontal tubular boilers of 225-H. P. capacity. The main building or drying floor has an area of 30,000 square feet. The hot-blast system utilizing waste heat from kilns is used in drying the ware. The ware is burned in nine down-draft kilns, 8 of which are 32 feet in diameter, and the other is 30 feet. The 2 storage sheds, with a total of 37,000 square feet floor space have a capacity of 7,000,000 brick. The plant is also provided with a machine and carpenter shop for general repair work, relining dies, and making molds. The shipping facilities are the Baltimore and Ohio Southwestern and the Norfolk and Western railroads.

The equipment of the Star plant is as follows: The raw materials are ground in two pans. The power is furnished by 3 engines, 2 automatic and 1 piston valve, with a total capacity of 175 H.P., the steam for which is generated in 2 horizontal tubular boilers with a total capacity of 150 H. P. The drying floors in the main building have a surface of 18,000 square feet. The drying is done the same as in the Portsmouth plant, i. e., by using the hot blast system of waste heat from the kilns. In the burning of the ware four 32-foot diameter and four 26-foot diameter kilns are used. The 2 storage sheds have a floor surface of 10,000 square feet and a capacity of 1,500,000 brick.

Both the Portsmouth and Star plants in 1915 were using natural gas for fuel at the boilers and kilns. The shipping facilities at this plant are the Baltimore and Ohio Southwestern, the Norfolk and Western railroads, and the Ohio River.

The 2 plants manufacture blast furnace linings, first and second quality stove brick, and ware for lime kilns, rotary cement kilns, boiler settings, locomotive arch work, gas producers, coke ovens, steel mills, and general purposes. The brands are as follows: Anglo Saxon, Franklin Crown, C. Franklin Crown, Malleable, Royal Star, C. Sligo, R. Jenkins, Scioto Star, and Webster. The ware is made from Sugarcamp flint clay mined at Edmunds near South Webster, and Blackfork plastic taken from the company's mines near Blackfork, Lawrence County. The first quality ware is high in refractory qualities withstanding a safe working temperature of 3,000° F. The clay mill at Edmunds has a dry pan with the necessary steam power for operation, and with screens to size the ground product. Several grades of clays are prepared for refractory ware mortars, and for other general purposes.

The following report concerning the plant of the Pyro Clay Products Company was furnished by the general manager, W. G. Griffiths:

The Pyro Clay Products Company commenced business in 1909. The plant is located near Rempel, Jackson County, Ohio, on the Ironton Division of the Cincinnati, Hamilton and Dayton Railway, and near the center of the Lower Kittanning coal field of Jackson County. Our supply of clay is received via the Baltimore and Ohio Southwestern Railroad, from mines near Gephart, Scioto County. We reach the Sciotoville clay which is largely worked in this locality by a shaft 80 feet in depth and equipped with a steam hoist. The mine is equipped with electric drills and is ventilated by a steam driven fan. The deposit of Sciotoville clay in this mine has an average thickness of about 6 feet and is evenly divided between flint and semi-flint, both of which have a high alumina content and are low in total fluxing impurities.

These clays are highly refractory, as they withstand without fusing a temperature of 3,300° F. The territory in which the mine is located was carefully tested with a diamond core drill, the tests being spaced 300 feet each way. The clay cores were analyzed by Prof. J. R. Withrow, of the Ohio State University, and the results show a large deposit of this valuable clay, amply equal to the demands of our plant for many years to come. The capacity of the mine at present is 100 tons per day, although a capacity of 150 tons may be reached on short notice. With the exception of small quantities of plastic clay which is necessary for the bonding component in some grades of ware, the Sciotoville clay is used exclusively in the manufacture of our refractory products.

The Oak Hill and Lower Kittanning clays outcrop in the hills adjacent to our plant. The latter is used for bonding clay and for some grades of ware which must be tough but only moderately refractory. Further the Clarion and Lower Kittanning coals have excellent volume in this locality and our supply of fuel is drawn from this source. The coal available is amply equal to the demands of the plant for many years. The beds are mined by drifting.

The plant is modern in every respect, well arranged for economy, and thoroughly equipped in every department. The power is furnished by two 18 x 72 boilers, with a 125-H.P. slide valve engine. Live and exhaust steam is used under the drying floors which have a total area of 16,000 square feet.

The floor is constructed of 3-inch sewer pipe laid in concrete, above which there is an additional coating of cement 3 inches thick. The floor is divided into 9 sections, any one of which may be heated independently. The crushing and tempering are done in 2 dry pans and in 1 wet pan. All clays are ground separately and conveyed to bins from which the clay is drawn into measuring cars equipped with movable partitions that enables the mixture of the different materials to be made in accordance with any formula desired. This permits of very uniform mixtures. While the clays from the Gephart mine are very uniform in quality, still great care is exercised in the selection of materials for different grades of ware. Special attention is bestowed on difficult shapes, and special facilities are provided for their manufacture. We take pains in the manufacture of the ware to meet the standards demanded by the trade with reference to shape, physical structure, and chemical properties. Four 3-foot kilns are now in operation, and others are under construction. These kilns are built so that the draft system is sufficient to produce the high temperature necessary for the thorough burning of high refractory ware. Ample storage is provided for the large and diversified stock that is kept on hand for immediate shipment.

The products are sold largely to steel and rolling mills, although they are used extensively in other lines where high-grade refractory ware is required. The capacity of the plant is 16,000 hand made brick per day. Our shipping facility is the Cincinnati, Hamilton and Dayton Railway.

GANISTER OR CLAY-BOND SANDSTONE ASSOCIATED WITH SCIOTOVILLE CLAY

The ganister or clay-bond sandstone found directly below, or interbedded with the Sciotoville clay, in a part of the clay field in eastern Scioto County, has not been manufactured into commercial ware as yet, but has been used occasionally to increase the silica content of fire brick. The sandstone below the clay deposit is really a part of the Sharon conglomerate, where it has assumed a sandy phase, and where the material at the time of deposition became admixed with argillaceous matter. The sandstone layers interbedded with the clay are also evidently derived from the conglomerate by secondary deposition. As these clay-bond sandstones or ganisters may be mined economically with the Sciotoville clay, and as they have excellent heat resisting qualities, they will be considered briefly. The quality of the clay-bond sandstone or ganister found below the Sciotoville clay is shown by a determination made by Downs Schaaf on a sample taken from the clay mine of William Tripp (Meade tract), in Section 25, Harrison Township. The rational analysis is as follows:

Quartz	82.96
Clay substance	15.90
Feldspathic matter	1.14

The material is low in fluxes and gave no test for CO_2. On breaking up the sample with a pestle in a mortar with as little grinding as possible it gave the following sieve test which shows the fineness of grain.

40-60 mesh	1.50	per cent
60-80 mesh	4.50	"
80-100 mesh	10.00	"
100 mesh	84.00	"

The clay-bond sandstone found interbedded with the Sciotoville clay in the Heldt mine of the Scioto Fire Brick Company, which is located near Gephart, was carefully sampled for a paper contributed to the American Ceramic Society, from whose transactions the following is taken:[1]

Silica, SiO_2	85.39
Alumina, Al_2O_3	9.48
Ferric oxide, Fe_2O_3	1.05
Lime, CaO	none.
Magnesia, MgO	.06
Titanic oxide, TiO_2	trace.
Alkalies, K_2O and Na_2O	.52
Ignition loss	3.53
Total	99.83

Fusion point, 3,150° F.

The sample of Gephart sandstone was reduced by a jaw crusher so that the largest pieces were about three-eighths of an inch in diameter. This crushed product was then made thoroughly wet and was allowed to stand over night so that it would come to an even temper. The tempered material was easily shaped into ware either by hand molding or by the dry press, as it had considerable plasticity or bonding power. The dried ware had sufficient strength to withstand the handling demanded in brick manufacture and to withstand the load attendant with setting. The working qualities of the Gephart sandstone are such that it may be made into a good clay-bond silica brick without the addition of extraneous material. When burned to cone 12 the brick had a linear expansion of 1.4 per cent. The Gephart sandstone produced a brick much harder than the original sandstone. It has a hardness near that of lime-bond silica ware.

The Scioto Fire Brick Company made a sample batch of brick from this ganister by grinding in the wet pan, and then hand molding the tempered material. The clay component in the ganister was sufficient in plasticity to thoroughly bond the mass. The burned ware has a good structure, and appears to be very satisfactory for most purposes where a clay-bond silica brick may be used. In some localities in Scioto County there are large quantities of this material which is worthy of thorough prospecting and testing.

ANTHONY COAL

The Anthony coal is associated with the Sciotoville clay, as has been shown in the general correlation of this clay, which was traced from the Ohio River in Scioto County to north of Jackson in Jackson County. This coal lies just above the Sciotoville clay, but with the exception of small areas in Green, Porter, and Bloom townships the bed is thin, seldom more than a few inches in thickness. As the position and structure of the coal are shown in many sections, which were given under the Sciotoville clay, it will be only briefly considered here.

Where found in Green Township the Anthony coal is only a few inches in thickness, and shaly in character. The horizon is above drainage along the river hills from Haverhill north to Pine Creek. The member is somewhat better developed in the eastern part of Porter

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[1] H B. Henderson and W. Stout, The Utilization of Ohio Clay-bonded Sandstones for the Manufacture of Silica Brick, Vol. XVIII.

Township, yet alone it is too thin to be considered an asset of value. In Section 22, on the farm of Caroline Gleim, the following record was obtained:

	Ft.	In.
Shale	7	--
Coal, *Anthony*, reported thickness	1	10

The Anthony coal was noted at a number of places on Lick Run, but the bed is everywhere thin or shaly. The following measurements, taken on the land of Joseph Miller, show the general thickness of the deposit in this locality:

	Ft.	In.
Ore, *Guinea Fowl*	--	10
Shale	17	--
Coal, *Anthony*	--	7
Clay, siliceous, *Sciotoville*	1	6
Sandstone, *Sharon*	7	--

In Section 1, on the Elizabeth Hurst property, the Anthony coal has been mined for local use, and is reported by Willard Hurst to be 1 foot 2 inches in thickness. The section taken near the pike was as follows:

	Ft.	In.
Coal, *Anthony*, reported thickness	1	2
Clay, flint, sandy, *Sciotoville*	2	6
Sandstone, light, fine-grained, *Sharon*	2	--

Although the Anthony coal is present in local areas in all parts of Harrison Township, where the Sciotoville clay is developed, it is best represented in that part east of the preglacial California Valley. The bed seldom exceeds 1 foot in thickness, while it usually measures only 2 or 3 inches. In the cut of the Baltimore & Ohio Southwestern Railroad in Section 36, Harrison Township, near Isaac Graham's house, the section exposed is as shown below:

		Ft.	In.
Coal, dense	*Anthony*	--	4
Shale		--	2
Coal, dense		--	7
Clay, flint, with scattered quartz pebbles, *Sciotoville*		5	6
Conglomerate, *Sharon*		20	--

The Anthony coal is found everywhere that the Sciotoville clay is present in the western part of Bloom Township, but in most of this area it is marked only by a smut streak or by a thin band of bony coal. However, near Gephart Station and on Frederick Creek, it thickens in restricted areas to a few inches. The Anthony coal in the Heldt mine near Gephart varies from a thin stain to 9 inches. A section in the main entry showing the relation of the coal to the Sciotoville clay follows:

		Ft.	In.
Coal, *Anthony*		--	9
Clay, flint	*Sciotoville*	1	4
Clay, semi-flint		3	--

In its extension into Madison Township but little change in the general character and in the mean thickness of the Anthony coal was observed, but in a few local areas it expands to 1 foot or more in thickness. The Anthony coal, locally well developed, was exposed on the property of R. A. Dever, in Section 20, west. The record measured follows:

	Ft.	In.
Ore, siliceous, with pebbles, *Guinea Fowl*	--	4
Shales, dark	6	--
Coal, good, *Anthony*	3	--
Clay, siliceous, *Sciotoville*	4	--

A section obtained on land of George Mouga, in Section 24, shows the Anthony coal associated with plastic clay. The measurement follows:

	Ft.	In.
Coal blossom, *Anthony*	--	8
Clay, plastic, *Sciotoville*	3	--
Shale and covered	8	--
Covered	39	--
Conglomerate, *Sharon*	8	--

The Anthony coal lying above the Sciotoville clay was seen exposed in the road along the line of sections 12 and 13, near the home of E. H. Lyons. In Section 11, the Anthony coal has been mined by drifting in a small way for local use. A small quantity of fuel has been mined on land of Francis Warren. Here this coal with the Sciotoville clay, Sharon ore, Sharon coal, and the massive Sharon conglomerate are found in about their normal positions. The following rocks were exposed for measurement:

	Ft.	In.
Coal, good, *Anthony*	1	3
Clay, dark, plastic, *Sciotoville*. On point to west both flint and "pink eye" clays seen on this horizon	3	--
Covered	16	--
Shale	2	--
Ore, *Sharon*	--	10
Covered	8	--
Sandstone	2	--
Coal blossom, *Sharon*, reported thickness for coal and partings	3	--

The coal has also been opened on land of William Lyons, in Section 10. The strata exposed were as follows:

	Ft.	In.
Coal, good, *Anthony*	1	6
Clay, plastic, *Sciotoville*	3	--

The Anthony coal is regularly associated with the Sciotoville clay in Clay and Jefferson townships, but the deposits are scarcely worthy of attention except for stratigraphic reasons. Along the road near the home of Joseph R. Keller, in Section 22, Jefferson Township, the following strata were exposed:

	Ft.	In.
Coal blossom, *Anthony*	--	6
Clay and clay shales	9	6

	Ft.	In.
Clay, flint, good, *Sciotoville*	1	3
Sandstone, shaly, ferruginous	--	6

The Anthony coal, varying in thickness from a thin stain to about 3 feet, is, with few exceptions, regularly associated with the Sciotoville clay. The usual thickness of the stratum is from 1 to 3 inches. The clay was laid down under coal forming conditions, which, due to a lack of vegetable life, or unfavorable agencies, preserved only thin deposits of carbonaceous matter as coal. The coal represents the closing stages of the swamp period.

Economic Value

The coal from the Anthony bed varies from a dense bony coal, which is high in ash, to one which is very low in ash and sulphur, and which has a clean bright fracture, or has often a cannel nature. A small quantity of coal has been mined by drifting from this bed on the Elizabeth Hurst property for domestic use. It has also been benched along the outcrop in a few localities. In the clay mines near Gephart this coal is taken down from above the clay, and is used locally. In the slope mines, where engines are used for hoisting, the supply obtained is often sufficient to produce the steam for the power. A small supply has been mined from the R. A. Dever deposit for local use, and it has also been worked at a few places in Madison Township near White Gravel Church. The following is an analysis of the coal taken from Steven's cut near Gephart, in Section 36, Harrison Township, by Prof. Wormley:[1]

Specific gravity	1.319
Combined water	4.40
Ash	5.75
Volatile matter	34.20
Fixed carbon	55.65
	100.00
Sulphur	.63
Ash, white.	

The area of coal on this horizon, with ample thickness to justify mining at present for the coal alone, is very small. Where mined along with the clay, it has some value, as the mining cost is then low. Counting 60 per cent available, a 10-inch bed will produce approximately 900 tons (2,000 lbs.) coal per acre; hence where coal and clay are mined from the same entry the former is an asset worth considering.

GUINEA FOWL ORE

The Guinea Fowl ore occurs above the flint clay of the Sciotoville member, but in some localities it is found in or below the plastic clay that lies above the flint. The interval from the flint clay to the ore varies from a few inches to 20 feet. A few sections only showing the relation of the ore to the coal, and to the clay will be given. In Section 36, Harrison Township, on the property of Jacob Bauer, the following section was exposed:

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[1] Geol. Surv. Ohio, Report for 1870, p. 164.

		Ft.	In.
Ore	*Guinea Fowl*	2	6
Ore, black band		--	6
Shale		10	--
Coal, one block, *Anthony*, reported thickness		1	8
Clay, flint, *Sciotoville*		2	--

In the clay mines of the Buckeye Fire Brick & Clay Company at Scioto Furnace, the relation is shown in the section given below:

		Ft.	In.
Ore, *Guinea Fowl*		--	4
Coal, *Anthony*		--	½
Clay, flint	*Sciotoville*	1	6
Clay, semi-flint		1	6
Clay, "pink eye," seen		3	--

On the property of Henry Moore, in Section 21, Bloom Township, the section exposed was as follows:

		Ft.	In.
Shale, black, with thin coal bands	*Quakertown*	--	4
Coal, solid block		1	5
Shale and covered		31	--
Ore, *Guinea Fowl*		--	6
Shale		6	6
Coal, *Anthony*		--	2
Clay, flint Clay, semi-flint	*Sciotoville*	3	--

In Section 20, Madison Township, on the land of R. A. Dever, the record shows the following relations of the Guinea Fowl ore to other members:

	Ft.	In.
Ore, siliceous, with pebbles, *Guinea Fowl*	--	4
Shales, dark	6	--
Coal, good, *Anthony*	3	--
Clay, siliceous, *Sciotoville*	4	--

Along the road near the home of Sampson Spriggs, in Section 10, Madison Township, an ore with well preserved plant impressions was seen on this horizon. The section measured follows:

	Ft.	In.
Ore, *Guinea Fowl*, fossiliferous	--	5
Sandstone, ferruginous	--	8
Shale and covered	10	--
Clay, plastic, light, *Sciotoville*	2	--

In Section 13, on land of Oliver Powell, the rocks seen and reported are as given below:

	Ft.	In.
Ore, *Guinea Fowl*	--	6
Shale	6	6

	Ft.	In.
Coal, *Anthony*, thickness reported found in well	1	6
Shale and covered	32	--
Covered	15	--
Conglomerate, *Sharon*	53	--

North of Sugarcamp Creek, in Section 5, on the land of Elizabeth Crabtree, the Guinea Fowl ore was exposed along the outcrop, and measured from 8 to 10 inches in thickness. It was of the limonite type and quite free from sand or pebbles. The interval from the ore to the Sciotoville clay below was not obtained..

The ore is wanting in many localities in Scioto County, but where found it varies in thickness from a few inches to 2 feet 6 inches, and has an average measurement of 5 or 6 inches. The distinguishing feature of this ore is the presence of quartz pebbles, varying in size from one-eighth to three-fourths of an inch, with some admixed sand. The ore is not a true conglomerate with the interstitial space filled with iron compounds, but a blue iron carbonate, when under cover, with a varying amount of pebbles. Usually the iron carbonate and not the pebbles make up the body of the ore. In some places it is practically free from pebbles.

The origin of the deposit is uncertain, as it presents features seldom observed in ore beds. The blue carbonate indicates quiet water deposition under swamp conditions, while the large pebbles point usually to the action of quite strong currents. The quartz pebbles were evidently brought in during the deposition of the ore. From the character of the pebbles they appear to have been derived from the Sharon conglomerate, which in places existed as islands during the swamp period when the ore beds were laid down, and not from distant sources, as the thin ore sheet would have been carried away by currents powerful enough to have transported the pebbles. Further, if the pebbles were deposited by strong currents the deposit would have been thicker and more irregular, and would not have been laid down in the thin, even bed found continuous for miles. Under these conditions too, the deposit would have been a conglomerate bed with later deposition from solution of the iron, which would fill only the interstitial spaces.

The lime content is high, while the phosphoric acid present far exceeds that usually found in coal measure ores. The lime was probably derived from two sources; part carried in as soluble carbonate by the small streams from the leaching of the siliceous rocks of the adjacent land areas, and part from the weathering and disintegration of Maxville limestone that in places existed as elevated beds, an example of which is seen in the remnart of this member found at the head of Holland Fork, Jackson County, far above the position of the Guinea Fowl ore. The phosphoric acid may have been derived from phosphatic shells or from the leaching and concentration of other rocks. The problem then is really one of precipitation as well as sedimentation. Some of the material may have passed through several cycles before final deposition.

The conditions most favorable for the deposition of bog ores are shallow quiet waters, and the presence of carbon dioxide, which conditions are best represented in shallow swamps or in the shallow shore waters of deeper basins. Calcium carbonate is also precipitated under somewhat similar conditions, and by the aid of algae which flourish best in the shallow waters. Calcium phosphate somewhat soluble in carbonic acid waters is also thrown down when considerable calcium carbonate is present. Therefore, the most likely types to form under swamp conditions from soluble iron, lime, and phosphorous compounds would be ferrous carbonate, calcium carbonate, calcium phosphate, and, if ferric hydrates are present, complex minerals of ferric phosphate with ferric hydrate. The evidence thus points to shallow water formation. The rigidity of the mass would depend on the cementing power of the minerals themselves, which is considerable, and on the binding from algae, rushes, etc. It thus appears that the pebbles from the Sharon conglomerate were irregularly distributed through this mass by local currents and by wave action during the entire period of formation.

Economic Value

The Guinea Fowl ore is generally very siliceous, owing to the admixed quartz pebbles and sand. Small deposits are found in Harrison, western Bloom, and eastern Madison townships. It was worked but little by the charcoal furnaces, and at present is far below the standard demanded by the modern furnaces. An analysis of this ore from a layer seen in the bed of the stream near Gephart's Station is as follows:[1]

Specific gravity	3.321
Siliceous matter	14.60
Sesquioxide of iron	10.50
Carbonate of protoxide of iron	42.58
Alumina	1.50
Manganese	trace
Calcium phosphate	13.40
Calcium carbonate	10.04
Magnesium carbonate	2.73
Water and loss	4.65
Total	100.00
Phosphoric acid	6.14
Metallic iron	26.69

The partial analysis of a sample from the William Tripp property, in Section 4, Bloom Township, where the ore is 18 inches in thickness, is as follows:

In upper 6 inches	iron, Fe	25.40 per cent
	siliceous residue	51.30 per cent
In lower 12 inches, iron, Fe		18.20 per cent

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[1] Geol. Surv. Ohio, Report for 1870, p. 165.

The ore has more value for the phosphoric acid content than for the iron. It has no economic importance at present.

The interval from the Guinea Fowl ore to the Quakertown coal is made up mainly of shales and sandstones interstratified, in which are found thin irregular deposits of clays, coals, and iron ores, none of which are important. One layer of the sandstone, known locally as the Hearth Stone rock, was used for lining Scioto Furnace while in blast. Some irregular deposits of carbonate ores and a layer of black band ore, which occurs from about 10 to 15 feet below the Quakertown coal, were worked. The clays are usually siliceous and the deposits thin, while the coals are only a few inches in thickness.

QUAKERTOWN, JACKSON HILL, WELLSTON, OR No. 2 COAL

Although the fields of Quakertown coal in Jackson County are of great economic worth, the deposits of this member in Scioto County have but little significance, except for their stratigraphic features. The horizon of the bed is found in every township east of the Scioto River, but it is marked by coal of sufficient thickness for utilization at only a few places. In parts of this area no trace of the coal, or even of its clay, are found, as the interval is taken by sandstones and shales.

Stratigraphy and Extent

The Quakertown coal lies about 35 feet above the Sciotoville clay and about 35 feet below the Bear Run coal. These intervals, however, vary considerably from place to place, and these three members are seldom well represented in the same section. The Quakertown coal is poorly developed in that part of Scioto County lying between the preglacial California Valley and the Scioto River. In a few localities, however, in western Harrison Township, the horizon of this member is marked by a thin bed of good coal. The deposits are quite local in extent as the coal lies closely below a massive sandstone, which replaces it in the greater part of the area. In Green Township a thin shaly bed of coal, which is found from 20 to 30 feet above the Sciotoville clay, appears to mark the horizon. The relation of this coal bed to the clay is shown in the following record measured on the lands of H. C. Feurt and A. J. Hyland, which are located south of Franklin Furnace:

	Ft.	In.
Coal, *Quakertown*	--	4
Clay	2	--
Shale	13	--
Ore, *Guinea Fowl*	--	4
Shale, blue	5	--
Coal blossom, *Anthony*	--	2
Clay, *Sciotoville*	4	10

This thin bed of Quakertown coal, lying about midway between the horizons of the Sciotoville clay and Bear Run coal, was noted also north of Franklin Furnace along the river hills, and west of the village of Powellsville along the valley of Pine Creek. However, no coal of value was found on the horizon. This stratum appears also in Porter Township, but in the same thin and shaly condition, while in Section 6, Vernon Township, 6 inches of Quakertown coal was exposed at a few places. The interval to the underlying Sciotoville clay in this locality, as nearly as could be determined, varies from 25 to 35 feet.

In the western part of Bloom Township local thickenings of the Quakertown coal occur, and the deposits have been mined in a small way for local consumption. In this township the coal is best developed in the vicinity of Scioto Furnace and along the headwaters of Bear Run. On the land of Henry Moore, in Section 21, the Quakertown coal and Sciotoville clay have both been mined. A section showing the following relations was obtained at this place:

		Ft.	In.
Shale		2	--
Shale, black, with thin coal bands	*Quakertown*	--	4
Coal, solid block		1	5
Shale and covered		31	--
Ore, *Guinea Fowl*		--	6
Shale		6	6
Coal, *Anthony*		--	2
Clay, flint	*Sciotoville*	3	--
Clay, semi-flint			

In the same section east of the above, the Quakertown coal has been opened and worked by farmers at several places. No sections were taken, but the structure is reported practically the same as noted on the Moore land. It has been opened also south of Scioto Furnace, in sections 28 and 29, but is reported thin. In the southwest corner of Section 7, on the property of William Tripp, the coal was again observed. The section follows:

	Ft.	In.
Coal, *Quakertown*, reported thickness	1	4
Shales and covered	35	--
Clay, flint, *Sciotoville*	3	--
Sandstones, shales and covered	32	--
Coal, *Sharon*, reported thickness	1	8
Conglomerate, *Sharon*	4	--

On Bear Run, one-half mile east of the Baptist Church, in Section 4, Bloom Township, on the William Tripp property (William Kinker tract), the Bear Run, Quakertown, and Anthony coals and the Sciotoville clay were found in the same hill. The following measurements were obtained:

	Ft.	In.
Coal blossom, *Bear Run*	--	6
Clay shales, dark	3	6
Shales, gray, and parts covered	28	--
Sandstones, flaggy and medium bedded	13	--

	Ft.	In.
Coal outcrop, *Quakertown*, seen to the south	1	8
Shales and covered	33	--
Sandstones	7	--
Coal, *Anthony*	--	2
Clay, flint, dark, *Sciotoville*	6	--

On this tract several small entries have been driven in the Quakertown bed in order to supply local needs. In Madison Township the Quakertown coal is thin or wanting, as the interval in a part of the region is made up of heavy sandstones.

Economic Value

The maximum thickness of the Quakertown bed found in Scioto County is 22 inches. The quality of the coal is very good. It is hard, bright, and burns with a free flame. The sulphur and ash contents are low. Where exposed, the floor of the coal is either a sandstone or a hard sandy clay, while the roof is a shale, except in a few places where the overlying sandstone has replaced this bed. This coal deposit, where exposed, is too thin to be mined at present, except for a small local domestic supply. The few drill records obtained in the territory east of the outcrop of the member fail to give any considerable thickness of coal on this horizon. As the associated materials have no value, and as the bed, where found, is thin and local, the Quakertown coal has no practical value in Scioto County.

BEAR RUN COAL

The Bear Run coal is found from 62 to 86 feet above the Sciotoville clay, or from 20 to 40 feet above the Quakertown coal. The average interval from the Bear Run coal to the Sciotoville clay is 71 feet, to the Quakertown coal 35 feet, and to the Lower Mercer coal 120 feet. In Scioto County this coal is much better developed than the underlying Quakertown, Anthony, or Sharon. The fossil horizon found associated with this member on Bear Run in Scioto County, on Holland Fork in southern Jackson, and near Petrea, northeast of the city of Jackson, is of some assistance in determining the position of the lower coal members. The Bear Run coal, although usually thin, or represented by carbonaceous shales, in local areas, has sufficient thickness for mining, and the coal is of good quality. The best deposits are found in Bloom Township, although the member is represented in Green, Porter, Vernon, Harrison, and Madison.

Green Township.—The Bear Run coal in Green Township is moderately persistent, but only in local areas has it sufficient thickness to attract mining, even for domestic consumption. The coal is usually somewhat bony and often of a cannel nature. In order to show its stratigraphic position and its general structure, a few sections will be given along its extension from the Ohio River northward into Porter

Township. The interval separating the Bear Run coal from the Lower Mercer was obtained on the property of C. A. Goddard at Junior Furnace. The measurements follow:

	Ft.	In.
Coal, *Lower Mercer*	1	2
Clay and covered	10	--
Sandstone	1	--
Shale	69	--
Sandstone, blocky, ferruginous	--	4
Shale	14	8
Coal blossom	--	6
Clay and shale	2	6
Sandstone	6	--
Shale	2	--
Coal, *Bear Run*	--	10

The Bear Run coal is unsteady and thin as it extends northward across the township from this place. It seldom thickens to over 1 foot, and is usually marked only by a few inches of coal or bony shales. In the hollow south of Pine Creek, and west of the Dark Lick School, the following record was obtained along the road that leads to the ridge south:

	Ft.	In.
Coal, bony, *Lower Mercer*	1	--
Shales and covered	33	--
Limestone, bastard	1	--
Shales and covered	30	--
Coal blossom, with bony shales, *Vandusen*	1	--
Shales and covered	45	--
Coal, *Bear Run*	--	9

This record was duplicated in the main at other places along Pine Creek, but as the coal was not found in good development other records will not be given. The interval between the Bear Run and Vandusen coals in the above record is somewhat greater than that usually found, as it is generally about 30 feet.

Porter Township.—The Bear Run coal has been mined in a small way by stripping, and from short entries at a few places in eastern Porter Township. The coal areas are small in extent, and the bed is uncertain in thickness and character. Sections taken in this township will be given in order to extend the bed northward into more productive fields. A composite record taken in sections 21 and 22, Porter Township, and in Section 30, Vernon, is given below:

	Ft.	In.
Coal, *Lower Mercer*	1	6
Clay	2	--
Shale, sandstone, and covered	95	--
Coal blossom, *Vandusen*	1	--
Clay shale	1	--
Sandstone, shaly, parts covered	13	--
Shale	6	--

	Ft.	In.
Coal blossom, *Bear Run*	1	--
Sandstone, massive	25	--
Shale and covered	30	--
Sandstone, blocky	5	--
Covered	22	--
Sandstone, blocky	4	--
Shale	7	--
Coal, *Anthony*	1	10
Clay, shale, and covered	20	--
Sandstone, massive, *Sharon*	25	--

The Bear Run coal has been mined by stripping at places along the Lick Run Valley, where it is about 1 foot in thickness. On the land of Mack Gifford, in Section 12, the bed is 8 inches in thickness, and lies about 130 feet below the Lower Mercer coal.

Vernon Township.—The Bear Run coal appears in the western part of Vernon Township, and at a few places it has been mined by stripping and by drifting. Although the bed is generally thin the coal is of good quality. In Section 6 the Bear Run coal has been worked for domestic fuel on the farms of Sarah J. Leesburg, Perry Jones, and Edward Turner. The measurements obtained on the Leesburg property are given below:

	Ft.	In.
Shale	1	--
Coal, *Bear Run*	1	2
Clay	1	--

This bed has also been mined by stripping on Lick Run, where it is reported to be about 1 foot in thickness. On the Frank Nagel property, in Section 19, the sandstones associated with the coal contain well preserved remains of coal formation plants. The Bear Run coal appears above drainage along Turkey Foot Run, in Section 29, where the following record was obtained on the land of David Lemon:

	Ft.	In.
Coal, *Vandusen*, reported thickness	1	10
Clay	3	--
Sandstone, shaly	6	--
Sandstone	11	--
Coal, *Bear Run*, cannel nature	1	10

Bloom Township.—Although the Bear Run coal is very unsteady in most of Bloom Township, in the northern part of the area it thickens sufficiently to be of some value for supplying local needs. It has its best development on Bear Run, in the northern part of the township, and in its extension northward into the Dever Valley, in southern Jackson County. In the area under consideration the best coal localities will be considered. In Section 20, just north of the clay mill of the Harbison-Walker Refractories Company, the Bear Run coal was formerly mined for use at Scioto Furnace. The thickness of the deposit reported by Ollie Downing is from 1 foot 3 inches to 4 feet. The section is as follows:

	Ft.	In.
Coal, *Bear Run*, reported thickness	3	--
Covered	3	--
Sandstone, massive	7	--
Covered, probably sandstone	8	--
Sandstone	13	--
Shales and covered	31	--
Coal, *Anthony*	--	2
Clay, flint and semi-flint, *Sciotoville*	5	--
Covered	2	--
Sandstone, *Sharon*	15	--

In Section 16 a composite measurement from a drill record made near the Baltimore & Ohio Southwestern Railroad, and from a carefully measured section north of this on the William Tripp property (Marsh tract), is as follows:

	Ft.	In.
Ore, *Lower Mercer* or *Little Red Block*	--	4
Shales and covered	44	--
Ore, *Boggs*, reported thickness	1	--
Shales and covered	36	--
Limestone, bastard, nodular, with calcite	1	--
Shales	10	--
Coal, *Vandusen*, reported thickness	2	3
Shales	8	--
Sandstone	11	--
Shales	3	--
Sandstone	5	--
Covered	27	--
Coal, *Bear Run*, reported thickness	1	5
Sandstone	6	--
Shales and covered	10	--
Top of drill hole.		
Surface	5	--
Sandy slate	5	6
Black slate } *Quakertown*	--	6
Coal	--	6
Clay mixture	8	--
Black slate	1	--
Slaty sandstone	5	6
Sandy slate	3	--
Slate	26	--
Bone coal, *Anthony*	--	4
Clay, flint and semi-flint, part sandy, *Sciotoville*	9	8

The material designated slate in the above drill record is shale. In the vicinity of the above sections the Bear Run coal, except in local pockets, is replaced by the underlying sandstone, or it is thin and shaly. The record obtained in Section 4, on the property of William Tripp, (Kinker tract), shows the Bear Run coal, and is given below:

	Ft.	In.
Coal, somewhat bony, cannel at times } *Bear Run*	--	10
Coal, good	1	6

		Ft.	In.
Clay		1	--
Covered		8	--
Sandstones, thin to medium bedded		14	--
Covered		35	--
Shale		3	--
Coal blossom, *Anthony*		--	1
Clay, dark, shaly	*Sciotoville*	9	--
Ore		--	3
Clay, flint, siliceous		2	--

This coal is quite persistent on Bear Run, and has been opened in a number of places. In some mines it is reported to have a maximum thickness of 3 or even 4 feet. In Section 3, on the H. H. Stevenson property, the coal has been mined for years for local use. The shale above the bed contains many fossils of *Lingula tighti*, which are also found on this horizon in many places in Jackson County. A section of the rocks at this place follows:

	Ft.	In.
Sandstone, massive	6	--
Shale, blue, tough, lower part fossiliferous	7	--
Coal, *Bear Run*, upper part somewhat bony	2	4

Also in Section 3, east of the above, and just south of the old Jackson Furnace stack, this bed was seen giving place to sandstone. The section showing the relation of the sandstone and coal is given below:

		Ft.	In.
Sandstone, massive		50	--
Coal, thickness irregular	*Bear Run*	--	2
Sandstone, thickness irregular		--	2
Coal, thickness irregular		--	7
Sandstone, with finger coal		4	--

On Tattle Creek, in Section 2, where it goes under cover, the Bear Run coal is only a few inches thick. What appears to be the same bed was reached by a shaft near Bloom Station in Section 24. The shaft record is not available, but William Downing reports that the bed, where reached, has good thickness, but that the coal is rotten and broken.

Economic Value

Of the now known areas of Bear Run coal in Scioto County, the only one of much promise is that on Bear Run in Bloom Township. Although the area here is small, not to exceed 2 square miles, the bed has ample thickness for mining. The material above the coal is usually a tough blue shale, which forms an excellent roof for mines. The clay, which lies under the coal, is ferruginous and siliceous, and has little ceramic value. The proximity of this small coal field to that of the Sciotoville clays on Bear Run and near Pinkerman should be an asset for any brick plants that may locate in the region. A 500 acre tract on which the coal is 2 feet thick, counting 60 per cent available in mining, will produce 1,062,000 tons (2,000 lbs.). For a plant using 50 tons per day for 300 days in a year this would run for over 70 years.

The coal in the upper part of the bed is somewhat bony, or it is of a cannel nature, but that in the lower part is a dense, bright coal of good quality. The coal in the deposit, as a whole, has a medium ash and a low sulphur content. It is an oily, free-burning coal, and the ash clinkers but little. Analysis of Bear Run coal, made for William Tripp, by the Star Furnace Co., Jackson, Ohio:

Moisture	7.67	per cent.
Volatile matter	38.58	"
Fixed carbon	46.85	"
Ash	6.90	"
Sulphur	.68	"

LINCOLN ORE

The Lincoln ore, which lies above the Bear Run coal, consists of irregular layers of limonitic kidney and carbonaceous shaly ores, occurring at different levels in the shales. The ore was worked, to a small extent, near Scioto Furnace for making charcoal iron, but as it is lean and uncertain the bed is not important at present. The Lincoln ore is found on the same general horizon as the Jackson Sand Block ore of Jackson County, but as both are erratically bedded and local in extent no definite correlation between the two deposits was established, further than that both occur in the interval between the Bear Run and Vandusen coals.

VANDUSEN COAL

The Vandusen coal lies about midway between the Bear Run and Lower Mercer coals. The interval from the Vandusen coal to the underlying Bear Run coal varies from 20 to as much as 60 feet, but it is usually about 30 feet. Further, the position of the bed is about 90 feet below the Lower Mercer or Little Red Block ore, or nearly 40 feet below the Lower Mercer coal. These beds, however, are erratically spaced, especially when the intervals contain massive sandstones. The member is present in Green, Vernon, Porter, and Bloom townships. The bed is generally quite thin, or it may be wanting; however, in small areas, it expands to such proportions that it has been mined to a limited extent for domestic needs. On account of its stratigraphic interest, and of its local worth, the member will be traced hurriedly, and the quality of the fuel discussed briefly.

Green Township.—In the main the Vandusen coal is poorly represented in Green Township. However, in the northern part, the bed in restricted areas expands so that it has been mined even by drifting. On the main ridge east of Pattons Run this coal was mined on the property of H. Miller, where the following measurements were obtained:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Covered, aneroid measurement	150	--

	Ft.	In.
Coal, *Vandusen*, reported thickness	1	8
Shale, sandstone, and covered	103	--
Sandstone	7	--
Disconformity.		
Clay, flint, *Sciotoville*	2	--

The member extends along the main ridge north of this, and has been worked also by drifting on the farm of E. H. Feurt, where it is reported to be from 1 foot 6 inches to 2 feet 2 inches in thickness. East and also south of the village of Powellsville a small quantity of fuel is obtained from this member. Measurements taken on the William Cook land are recorded below:

	Ft.	In.
Ore, nodular, siliceous	--	6
Shale, with layers of nodular ores	23	6
Sandstone	1	--
Shale	2	--
Coal, *Vandusen*, reported thickness	1	8
Clay	2	--

North of Powellsville this coal has also contributed a small quantity of fuel for domestic purposes, and on the farm of Joseph Riepenhoff the coal is reported to be 1 foot 8 inches in thickness.

Porter Township.—From Green Township the Vandusen coal extends northward into Porter, but here it is usually thin, seldom exceeding 1 foot in thickness. It has not been mined to any considerable extent even by stripping.

Vernon Township.—The Vandusen coal is somewhat better developed in Vernon Township, and in some districts it has been mined by drifting in a desultory way. The productive areas, however, are small, but as the fuel is of good quality, and other beds poorly represented, it is worthy of consideration. On the farm of John Sweinberger, in Section 17, the bed has the following structure:

	Ft.	In.
Sandstone	5	--
Coal, *Vandusen*	2	--
Clay, siliceous	2	--

A section measured along the road on the east side of the Cadot Hill, in Section 22, shows the position of the Vandusen coal with respect to that of other members. Owing to the influence of thick sandstones a few of the beds are somewhat out of their normal positions. The record follows:

		Ft.	In.
Coal	*Tionesta*	1	1
Clay		1	6
Coal		--	6
Covered		5	--
Sandstone		2	--
Shale, dark		2	--

	Ft.	In.
Sandstone	5	--
Shale and covered	16	--
Sandstone	1	--
Coal	--	4
Covered	6	8
Sandstone	11	--
Covered, *Upper Mercer* ore near top of interval	26	--
Coal blossom, *Upper Mercer*	1	--
Covered	11	--
Sandstone and covered	10	--
Clay shale	3	--
Shale	7	--
Sandstone, shaly	1	10
Ore, *Lower Mercer*	--	2
Shale and covered	13	--
Sandstone, shaly, parts covered	28	--
Coal blossom, *Lower Mercer*	--	6
Clay	--	6
Covered	16	--
Sandstone	3	--
Shale	2	--
Coal, *Vandusen*	1	6
Clay	5	--
Sandstone and covered	20	--
Coal, cannel, *Bear Run*, lenses in sandstone	--	6

Just east of this in the same section the Vandusen coal has been mined by drifting and by stripping on the farm of Elias Weaver, where it is reported to be about 1 foot 6 inches in thickness. Along Turkey Foot Run this coal outcrops at many places and has been worked for local use. It is usually about 1 foot 6 inches thick; however, in restricted areas, it expands to about 2 feet. The following measurement was made on the farm of C. O. Turner, in the northeastern part of Section 9:

	Ft.	In.
Shale, black	2	--
Coal, cannel, *Vandusen*	1	6
Shale, black, carbonaceous	1	6

House coal is also obtained on the property of S. R. Jones. On the land of David Lemon, in Section 8, a local thickening of the Vandusen coal also occurs. The bed contributed fuel for several years, and from reports the area is not yet exhausted. Both the Vandusen and Bear Run coals are present near his residence, where the record given below was obtained:

	Ft.	In.
Coal, *Vandusen*	1	10
Clay	3	--
Sandstone, shaly	6	--
Sandstone	11	--
Coal, *Bear Run*, somewhat bony	1	10

The Vandusen coal, about 1 foot in thickness, was exposed along a small stream on the farm of John Summers, in Section 5.

Bloom Township.—The Vandusen coal has much the same character and structure in Bloom Township as it has in Vernon. At some places it thickens so that it has been mined by drifting for domestic fuel. The best exposures observed will be recorded, and its stratigraphy considered in a general way. On the property of H. O. Stiles, in Section 22, the record measured is as follows:

	Ft.	In.
Ore, *Little Red Block* or *Lower Mercer*	--	4
Shale, sandstone, and covered	54	--
Coal, *Lower Mercer*	1	6
Shale and covered	18	--
Coal blossom	--	6
Shale	5	--
Shale and covered	8	--
Coal, *Vandusen*, reported thickness	1	3

In Section 16, a measurement, taken on the property of William Tripp (Marsh tract), shows this coal and its relation to other members. The section is given below:

	Ft.	In.
Ore, *Lower Mercer* or *Little Red Block*	--	4
Shales and covered	44	--
Ore, *Boggs*, reported thickness	1	--
Shales and covered	36	--
Bluish limestone, nodular, with calcite	1	--
Shales	10	--
Coal, *Vandusen*, reported thickness	2	3
Shales	8	--
Sandstone	11	--
Shales	3	--
Sandstone	5	--
Covered	27	--
Coal, *Bear Run*, reported thickness	1	5

A section taken in a mine on the same property (Haines tract) shows the structure of the bed to be as follows:

		Ft.	In.
Ore, *Lower Mercer* or *Little Red Block*		--	4
Shale, sandstone, and covered		90	--
Shale		4	--
Coal, bony, fissile	*Vandusen*	--	2½
Coal, good, bright		1	8½
Coal, bony		--	2

A few openings have been made to the west of the above mine, but no measurements of the bed were taken. This coal was also mined south of South Webster, on the land of the Webster Brick Co. The following record showing the interval to the Little Red Block ore was taken near the plant:

	Ft.	In
Ore, *Little Red Block* or *Lower Mercer*	--	4
Covered	8	8
Shale	7	--
Sandstone, blocky, shaly	1	--

		Ft.	In.
Shale, sandy		4	--
Shaly sandstone		--	4
Coal		--	3
Shale, blue, sandy		2	3
Sandstone, irony		--	7
Sandstone		--	3
Shale, gray		2	5
Shale, blue		1	--
Bone shale, dark		--	4
Shale, blue, tough		1	7
Bone shale, dark		--	7
Clay, sandy		1	--
Shale, blue		6	8
Coal	*Boggs* ore horizon	--	1
Clay, shaly, blue, sandy, plant marked		1	7
Coal, bony		--	4
Clay, dark, sandy		1	--
Clay, light, sandy		2	--
Shale		35	--
Coal, *Vandusen*		--	10

At this place the thickness of the bed is reported to vary from 10 inches to 1 foot 6 inches. It is also exposed in a number of places near Bloom Junction, where the thickness of the member is only a few inches.

Economic Value

Although the economic value of the Vandusen coal in Scioto County is small, yet it is worthy of consideration, for the member affords a small quantity of fuel for local consumption in regions where thicker coals are seldom present. Owing to the patchy nature of the bed it is difficult to give an estimate of the total area in which the coal has a thickness of 1 foot 6 inches or more, but from surface and mine observations the field appears to be between 5 and 10 square miles in extent. The mining conditions of the Vandusen coal are usually good, as the roof is either a tough shale or a sandstone, and as the floor is a siliceous clay. The latter, however, has but little value for ceramic purposes; hence there are no special inducements to mine both beds conjunctly. The Vandusen coal resembles closely the Mercer coals in general properties. It is a bright, hard fuel, with a high content of volatile matter, and in the regions where the bed is placed between sandstones it tends towards a true cannel coal. The ash is clay-like in character, and is moderate in amount when the coal is cleanly mined. The content of sulphur is usually low, while the soot produced is not troublesome. The chief value of the Vandusen coal in Scioto County is for local domestic use, for which it is well fitted.

LOWER MERCER SHALES

In the interval from the Vandusen coal to the Lower Mercer coal, and in fact to the Lower Mercer limestone, thick shale deposits, which are well fitted for the manufacture of ceramic products, are found in Green, Vernon, and Bloom townships. The shale overlying the Vandusen coal in many localities has a thickness varying from 10 to 40 feet, but so far it has been utilized at only one place, which is at South Webster, where it is used by the Webster Brick Company in the manufacture of paving and building brick. The bed at this place is 35 feet in thickness. It is also shipped to roofing tile plants at Cincinnati. It is a compact, fine-grained shale, but weathers easily to a plastic mass. The working qualities of the shale are very good, as it dries safely in almost any type of drier, and as it burns to a dense mass with good color. The total shrinkage is one and one-fourth inches per foot, and the vitrification range is moderately long. The Webster Brick Company uses the Lower Mercer shales from the Vandusen coal to the Little Red Block ore in the manufacture of paving brick. H. M. Strong, secretary and general manager, reports as follows concerning the general plant equipment:

> The plant is located at South Webster, just south of the village. The company added extensive improvements in 1913-14, so that at present it is a modern plant in every respect. The material used is shale which is mined from the hill just south of the plant by the open pit method of mining.
>
> The plant equipment is one Raymond and two Stevenson 9-foot dry pans, one Raymond 9-foot pug mill, one E. M. Freese Model 'K' combination brick machine, a No. 20 automatic cutter, and two Bonnot represses. The tunnels for drying have a total capacity of 100,000 brick. The drying is done by waste heat from the kilns, and, if necessary, direct heat from an auxiliary furnace. The ware is burned in round down-draft kilns. The number, size, and capacity are as follows: six 28-foot, capacity each 45,000; seven 30-foot, capacity each 65,000; and one 32-foot, capacity 70,000. The brick are shipped by way of the Baltimore & Ohio Southwestern Railroad. The capacity of the two sidings at the plant is 30 cars. The daily capacity of the plant is 40,000 standard size paving brick.

LOWER MERCER, OR No. 3 COAL

The next member of noteworthy importance found above the Vandusen coal in the geological column is the Lower Mercer coal which is present in Green, Porter, Vernon, and Bloom townships. The Lower Mercer coal is the first important bed of coal below the Lower Mercer ore, from which it is separated by a mean interval of about 45 feet. Further, its position is nearly 45 feet above the Vandusen coal, and about 100 feet below the Upper Mercer ore. Although the bed is usually thin, it has fair continuity, and has contributed small quantities of fuel for domestic use.

Green Township.—In Green Township the Lower Mercer coal has a thickness of 1 foot or more in an area embracing several square miles, and is mined by drifting for a part of the local fuel supply. It has been worked by stripping along the stream beds in the vicinity of Ohio Furnace, but the coal is only about 1 foot in thickness. The relation of the Lower Mercer coal to other members is shown in the following record, taken about one-fourth mile north of the old furnace on the land of the Hanging Rock Iron Company:

	Ft.	In.
Coal blossom, *Tionesta*	1	--
Sandstone and covered	13	--
Ore, *Upper Mercer*	1	--
Shale and covered	17	--
Sandstone	21	--
Coal	--	2
Shale and shaly sandstone	25	--
Shale	6	--
Coal	--	6
Clay, siliceous	2	6
Shale and shaly sandstone	41	--
Coal, *Lower Mercer*	--	10

West of Ohio Furnace the Lower Mercer coal is rather persistent along Genats Run, and has been mined in a small way on the land of George Porter, where the deposit is reported to be 2 feet in thickness. On the ridge south of Junior Furnace, on the C. A. Goddard property, the structure of the bed is reported by Arthur Goddard to be as follows:

		Ft.	In.
Coal	*Lower Mercer*	1	10
Coal, bony		--	4
Coal		--	10
Clay		1	--

In Bowman Hollow north of Junior Furnace the following measurements were obtained at the mine of W. M. Gallion:

	Ft.	In.
Ore, *Upper Mercer*, reported thickness	1	6
Covered	58	--
Sandstone	1	--
Shale	9	--
Covered	32	--
Sandstone	3	--
Shale, arenaceous	2	6
Coal, *Lower Mercer*	1	10

In this locality the coal is reported to be quite constant in thickness, as it varies only from 1 foot 8 inches to 2 feet. On the hill just west of Junior Furnace the Lower Mercer coal has been prospected by a short entry, and is reported by Arthur Goddard to be about 1 foot 2 inches thick. North of this along Franklin Hollow the bed is stated to be somewhat better developed in local areas.

The interval from the Lower Mercer coal to other members higher in the geological column is shown by the following measurement of the rocks exposed along the road at the head of Franklin Hollow:

	Ft.	In.
Ore, *Upper Mercer*, reported thickness	--	8
Covered	23	--

	Ft.	In.
Sandstone	1	--
Coal blossom, *Upper Mercer*	1	--
Clay	2	--
Sandstone	10	--
Covered	53	--
Coal blossom, *Lower Mercer*	--	6

In the vicinity of Franklin Furnace the Lower Mercer coal is usually present in about its normal thickness. A record obtained on the land of Wesley Blair shows the following conditions:

		Ft.	In.
Coal	*Lower Mercer*	1	--
Coal, bony		--	1½
Coal		--	8

East of this, on the farm of William and Walter Silliman, the Lower Mercer coal is mined by drifting, where the coal measured 1 foot 10 inches. On the main ridge, about one mile north of Franklin Furnace, the Lower Mercer coal has been mined in a small way at a few places.

The maximum thickness of the bed in this locality is stated to be about 2 feet. Along Pine Creek in Green Township, the Lower Mercer coal is usually thin, and in places very bony. Further, the bed has not been mined, except by stripping along the stream beds, where the cover is shallow.

Porter Township.—The Lower Mercer coal is found near the summits of the high ridges in the eastern part of Porter Township, but it has been mined in only a few localities, and there in a small way only for local domestic needs. The measurements given below were taken in a mine and well under cover on the property of Warren Turner, in Section 20:

	Ft.	In.
Shale, hard	--	10
Coal, *Lower Mercer*	1	7
Clay	2	--

This bed is also mined by drifting on the farm of Frank Riepenhoff, in Section 13, where the coal measured 1 foot 8 inches, and lay 40 feet below the Lower Mercer ore. The coal in this locality is stated to have a thickness varying from 1 foot 6 inches to 1 foot 10 inches. North of this in Section 12 the bed has been prospected on the land of Mack Gifford, and is reported to be 1 foot thick.

Vernon Township.—The Lower Mercer coal in Vernon Township contributes at present only a small quantity of fuel for local domestic purposes. It is generally thin, and in some localities where massive sandstones prevail it is patchy or completely wanting.

The Lower Mercer coal has been mined on the farms of James Chapman and Clinton Nichols, and is stated to be from 1 foot 6 inches to 1 foot 9 inches in thickness. Along Pine Creek, in the eastern part of Vernon Township, the Lower Mercer bed is usually made up of thin layers of coal and of bony shales. Measurements taken about one mile north of Clinton Furnace, in Section 23, show the relation of the Lower Mercer coal to the Lower Mercer limestone and to other members of importance. The composite section is given below:

	Ft.	In.
Ore, *Ferriferous*, reported thickness	--	8
Sandstone and covered	59	--
Coal blossom, *Tionesta*	1	--
Clay shale, siliceous	10	--
Covered	10	--
Sandstone, massive	43	--
Covered	15	--
Shale	2	--
Coal blossom	--	2
Covered	2	--
Ore, *Sand Block*	--	4
Shale and covered	11	6
Shale, black	1	--
Coal, *Upper Mercer*	1	6
Clay	6	4
Shale	3	8
Coal stain	--	1
Clay shale	1	--
Sandstone, shaly	8	--
Covered	7	--
Limestone, arenaceous, fossiliferous, *Lower Mercer*	1	--
Covered	4	4
Sandstone	2	--
Shale	6	--
Covered	32	--
Ore, nodular	--	4
Shale and shaly sandstone	4	8
Shale, dark	1	6
Coal, *Lower Mercer*	1	--

In Section 10, north of the village of Lyra, on the farm of Susan Newland, the following record which shows the Lower Mercer coal to be of a cannel type was obtained:

	Ft.	In.
Coal, *Upper Mercer*	2	--
Sandstone and covered	40	--
Ore, *Lower Mercer*, reported thickness	--	10
Shales and covered	52	--
Coal, cannel, *Lower Mercer*, reported thickness	2	2

The Lower Mercer coal is mined in a small way for house use on the farm of Warren Call, in the northern part of Section 30, where it was found to be 1 foot 6 inches thick. In Section 18 the Lower Mercer coal is mined for domestic use on the farm of Joseph Sweinberger, and is reported to be about 1 foot 8 inches thick.

Bloom Township.—Although the Lower Mercer coal is poorly developed in most of Bloom Township the horizon is usually marked by dark fissile shales with thin layers of coal. However, at a few places, the bed has much the same general character as it has in the townships to the south. A few sections will be given in order to extend the stratigraphy of the member into Jackson County. On the land of John Slack, in Section 25, the Lower Mercer coal with other members was exposed for measurement, and the following record obtained:

	Ft.	In.
Coal, *Webster Block*	1	6
Clay	3	--
Covered	8	6
Ore, *Little Red Block* or *Lower Mercer*	--	4
Shale and covered	43	--
Sandstone, plant marked	1	--
Ore, *Boggs*, 1 foot thick seen across hollow on this horizon.		
Shale	3	--
Coal blossom, *Lower Mercer*	1	--

In Section 22, on the land of H. O. Stiles, the Lower Mercer coal has been opened. The section is as follows:

	Ft.	In.
Ore, *Little Red Block* or *Lower Mercer*	--	4
Shale, sandstone, and covered	54	--
Coal, *Lower Mercer*	1	6

Just north of the Stiles home this bed was opened and worked at one time, and the coal is reported 3 feet thick. The Lower Mercer coal has also been worked on the lands of Charles Dillon and George Emerson, in Section 2. The record taken at this place is given below:

	Ft.	In.
Ore, *Boggs*, fossiliferous	1	--
Shale and covered	3	--
Coal, *Lower Mercer*, reported thickness	2	--

Economic Value

The chief worth of the Lower Mercer coal in Scioto County is for local domestic needs. As the bed is found in a region where the thick Allegheny coals are absent, and where the other Pottsville coals are also thin, it adds materially to the resources of the region at present, and will become of more value in the future. Counting 60 per cent available, the bed where it is 1 foot 8 inches in thickness will yield about 2,000 tons of fuel per acre. As the bed extends across the county, and as in a number of localities it has the thickness just mentioned, the quantity of fuel available is amply sufficient to supply the needs of the local residents for many years. The Lower Mercer coal is a free-burning fuel, which at some places, as previously shown, tends towards the cannel variety. The ash and sulphur are ordinarily somewhat high, but not to such an extent as to be troublesome for general purposes. The underlying clay has no special value, but it and the associated shales may be utilized for ceramic products where other conditions are favorable for the success of such industries.

BOGGS ORE

The Boggs ore lies from 40 to 55 feet below the Little Red Block ore, which is near the horizon of the Lower Mercer limestone. The average interval from the Boggs to the Little Red Block ore is about 47 feet. The ore is best represented in Bloom Township near South Webster, but it is also found in Vernon Township, where it is known locally as the Flag ore. It is an argillaceous or shaly siderite ore usually low in iron, but often carrying appreciable amounts of lime and magnesia. The ore is not persistent, but is found only in isolated pockets. Where present, the thickness may vary from a few inches to as much as 6 feet, but the average measurement is about 2 feet. The appearance and composition of the ore suggest swamp origin, or that it was laid down in shallow water where the ferrous carbonate was precipitated, and where also argillaceous and arenaceous materials were accumulating as sediments. The Lower Mercer coal is closely associated with the Boggs ore. Its position is a few feet below the ore, and, in fact, several thin coals are found on this general horizon. The following measurement was taken in Section 25, Bloom Township, on the property of John Slack:

	Ft.	In.
Coal, *Webster Block*	1	6
Clay	3	--
Covered	8	6
Ore, *Little Red Block* or *Lower Mercer*	--	4
Shale and covered	43	--
Sandstone, plant marked	1	--
Ore, *Boggs*, 1 foot thick, seen across hollow on about this horizon.		
Shale	3	--
Coal blossom, *Lower Mercer*	1	--

In the northwest corner of Section 22, on the property of W. E. Ranchous, and others, the ore was worked by drifting for the Jackson furnaces. The bed was reported to be from 1 to 4 feet in thickness, and to lie 44 feet below the Lower Mercer ore. In Section 15, just west of South Webster, a record taken on the property of Jefferson Mossbarger is as follows:

	Ft.	In.
Ore, *Big Red Block* or *Upper Mercer*	--	5
Shale and covered	27	--
Coal, *Webster Block* or *Upper Mercer*	1	4
Shale and covered	20	--
Ore, *Little Red Block* or *Lower Mercer*	--	4
Shale and covered	38	--
Ore, *Boggs*, reported thickness	1 to 6	--

The ore has been opened on the property of James Haines, and also on that of S. H. Wiseman and S. G. Huffman, east of South Webster. On the property of William M. Galliger, south of Bloom Station, in Section 24, the following strata were exposed:

		Ft.	In.
Sandstone, with finger coal at bottom		15	--
Disconformity.			
Shale, dark, tough, fissile		1	3
Ore	*Boggs*	--	4
Shale, blue		--	2
Ore		--	11

On the land of Charles Dillon, in Section 2, Bloom Township, a record showing the Boggs ore and the underlying Lower Mercer coal follows:

	Ft.	In.
Ore, fossiliferous, *Little Red Block*	--	4
Shale and covered	53	--
Ore, *Boggs*, siliceous, fossiliferous	1	--
Shale and covered	3	--
Coal, *Lower Mercer*, reported thickness	2	--

In Section 11, on the property of John Kinker, one mile north of South Webster, where the ore was mined for the charcoal furnaces, the record obtained shows the following strata:

	Ft.	In.
Ore, *Little Red Block* or *Lower Mercer*	--	8
Covered	38	--
Sandstone	3	--
Shale, tough, dark, fissile	1	--
Shale, gray	4	--
Shale, dark	1	6
Coal	--	6
Ore, *Boggs*	2	6

On the land of William Russ, Section 13, the ore is again present, and the section measured follows:

	Ft.	In.
Shale and covered	10	--
Ore, *Boggs*, reported thickness	1 to 2	--

The Boggs ore extends south from eastern Bloom Township along Hale's Creek and along Pine Creek to the vicinity of Lyra, in Vernon Township. In this locality, however, the bed becomes more impure, and finally breaks up into thin, irregular layers, interbedded with shales, and has no special value.

The Boggs ore occurs only in isolated pockets in Bloom and Vernon townships, but where present, especially in the former township, it usually has a thickness varying from 1 to 6 feet.

Economic Value

The weathered ore from along the outcrop of the deposit was first used by the old charcoal furnaces in the region. Later the ore near South Webster was mined quite extensively and shipped to the coke furnaces at Jackson, Ohio. Many of the known ore pockets have been worked only along the outcrop, and as the stratum usually has excellent volume the quantity yet available is large. The method of mining would be by drifting.

Analyses of the Boggs ore collected from various sources:

Sample	No. 1	No. 2	No. 3	No. 4	No. 5
Metallic iron, Fe	31.12	31.75	34.7	25.05	20.95
Silica, SiO_2	7.88	12.61	22.4	41.00	
Alumina, Al_2O_3	1.25	3.03			
Lime, CaO	10.77	4.15	3.0		
Magnesia, MgO	.95	.59			
Manganese, Mn	.51	.46			
Sulphur, S	.45		.231		
Phosphorus, P	.351	.302	.557		
Ignition loss	28.77	24.99	24.0		
Hydroscopic water	.25	7.85	4.6		

Sample No. 1—Air dried, from William M. Galliger property, Section 24, Bloom Township.

Sample No. 2—Average sample of bed, natural state, same property as above.

Sample No. 3—Geol. Surv. of Ohio, Vol. 5, page 422.

Sample No. 4—Sample from outcrop. John Kinker property, Section 11, Bloom Township.

Sample No. 5—Sample from outcrop. Smith Hayward property, Section 35, Bloom Township.

All analyses except No. 3 were made by the author for the Columbus Iron and Steel Company, and are given by its permission.

The ore averages low in iron, consequently if used in the raw state it would give a small yield in the blast furnace. The siliceous content shown by some of the above analyses is not excessive, and the lime and magnesia increases the value somewhat. The phosphorus, which is high, restricts the use mainly for foundry iron, while the manganese content is about that found in the average ore. The main use of this ore should be to furnish the siliceous part of the ore desired in making high silicon and foundry iron, and to replace the highly siliceous Lake ores used at present. For this purpose the Boggs ore should produce fair results. As the ore is a blue carbonate, the volatile matter is exceptionally high; hence calcination will increase considerably the non-volatile constituents. By calcination, samples No. 1 and No. 2 become as follows:

Sample	No. 1	No. 2
Metallic iron, Fe	45.78	47.28
Silica, SiO_2	11.58	18.78
Alumina, Al_2O_3	1.84	4.51
Lime, CaO	15.83	6.18
Magnesia, MgO	1.40	.88
Manganese, Mn	.75	.69
Sulphur, S	.66	----
Phosphorus, P	.516	.445

The calcined ore is much richer than many of the siliceous Lake ores on the market.

INTERVAL FROM THE BOGGS TO LITTLE RED BLOCK OR LOWER MERCER ORE

In the interval from the Boggs ore to the Little Red Block ore or Lower Mercer limestone, several thin coal beds are represented, but they are not important. The horizon of the lowest bed is just above the Boggs ore level, and between this and the Little Red Block ore, two other horizons, somewhat persistent, are represented by thin coal beds, dark bony shales, or soft clays. These coals, usually only a few inches in thickness, have been mined at a number of places from the beds of streams. Small quantities of fuel, very good in quality, have also been obtained from them by stripping along the outcrop under shallow cover. The clays associated with these coals are small in volume and poor in quality. The shales occurring in this interval, however, are more important. Some strata are of excellent quality for the manufacture of building and paving brick, and are used for this purpose by the Webster Brick Company. The working qualities are good. The shales are readily crushed in the dry pan. Good plastic muds, which flow readily through the die of the brick machine, and which produce a column with but few defects, are readily formed by pugging. The ware made from these shales dries safely under almost any treatment, and, when burned, it has a good dense structure. The total shrinkage, both drying and burning, is generally about one and one-fourth inches per foot. As there are so many other good clay and shale deposits, these beds are an asset only when favorably located with reference to shipping facilities, coal supply, labor, ease of mining, etc.

LOWER MERCER OR LITTLE RED BLOCK ORE, AND LOWER MERCER LIMESTONE

The Lower Mercer or Little Red Block ore lies on or only a few feet above the Lower Mercer limestone when both are present. In Scioto County the ore is far more persistent than the limestone, for the former is found in Green, Vernon, eastern Porter, and Bloom townships, while the latter was noted in good development only in Vernon Township along Pine Creek, south of the village of Lyra. These members lie about 45 feet above the Lower Mercer coal, about 22 feet below the Upper Mercer coal, and about 52 feet below the Upper Mercer or Franklin ore. Both the Lower Mercer ore and limestone are fossiliferous, but the ore contains fewer specimens than the underlying limestone. Sections will be given in order to show the relation of these members to other well known beds.

Green Township.—Near the summit of the hill along the road that leads from Haverhill to Ohio Furnace, a few inches of flinty material, which represents the Lower Mercer limestone, was noted. The following measurements of the rocks at this place show the position of this flinty limestone with reference to other important beds:

	Ft.	In.
Coal blossom, *Tionesta*	--	6
Clay	1	6
Sandstone and covered	29	--
Shale and covered	18	--
Ore, *Upper Mercer*	--	4
Sandstone	2	--
Shale and covered	36	--
Coal blossom, *Upper Mercer*	--	6
Clay	3	6
Shale	6	--
Coal blossom	--	2
Clay and clay-bond sandstone	7	10
Sandstone	1	6
Shale and shaly sandstone	27	--
Coal blossom	--	2
Clay shale	1	6
Sandstone	3	8
Coal blossom	--	2
Clay shale	1	--
Shale and shaly sandstone	15	--
Flint and ore, *Lower Mercer*	1	--

The interval between the two Mercer horizons in the above section is greatly expanded, as it has nearly twice the normal thickness. There is a gradual thinning of the interval, however, as it passes northward. Although the Lower Mercer ore is seldom present in the vicinities of Junior and Franklin furnaces, the horizon is generally marked by a thin bed of coal, the position of which is from 60 to 70 feet below the Upper Mercer ore which is quite steady.

Porter Township.—The Lower Mercer ore is present at a number of places near the summits of the hills in the eastern part of Porter Township, but the limestone of this division of rocks was nowhere observed. The ore is thin and siliceous; hence it has no value worthy of consideration.

Vernon Township.—In Vernon Township, the Lower Mercer ore is moderately persistent, and the limestone is present in force along Pine Creek south of the village of Lyra. The area, however, in which the limestone is found is small, yet at places it has the characteristic structure seen in northern Jackson and southern Vinton counties. A record obtained along the road that leads from Poplar Fork to Clinton Ridge, in Section 28, shows the following general positions of the Lower Mercer ore and other members. The record is given below:

	Ft.	In.
Limestone, *Ferriferous*	2	--
Sandstone and covered	54	--
Coal, *Tionesta*	1	--
Shales and covered	32	--

	Ft.	In.
Ore, *Upper Mercer*	--	4
Shales and covered	22	--
Coal blossom, *Upper Mercer*	1	--
Sandstone and covered	19	--
Ore, *Lower Mercer*	--	3
Covered	55	--
Coal, *Lower Mercer*	1	8

On the land of Thomas Patton, in Section 24, the Lower Mercer limestone has the characteristic structure found in northern Jackson County. Both benches of limestone are present and have normal volume. The measurements secured are given below:

		Ft.	In.
Limestone, gray, fossiliferous	*Lower Mercer*	1	--
Shale		--	4
Limestone, blue, fossiliferous		1	10

South of the village of Lyra, on the C. F. Taylor property, the Lower Mercer limestone, with the Upper Mercer coal, was exposed for measurement, the results of which are given below:

		Ft.	In.
Shale		--	8
Coal	*Upper Mercer*	2	1
Shale, bony		--	6
Coal		1	5
Clay		2	--
Sandstone		10	--
Shale		6	--
Sandstone and shale		9	
Limestone, *Lower Mercer*		1	

In Section 10, north of Lyra, on the property of Susan Newland, the positions of the Upper Mercer and Lower Mercer coals, with regard to that of the Lower Mercer ore, are shown by the following record:

	Ft.	In.
Coal, *Upper Mercer*, reported thickness	2	--
Sandstone and covered	40	--
Ore, siliceous, *Lower Mercer*	--	10
Shales and covered	52	--
Coal, *Lower Mercer*, reported thickness	2	2

Bloom Township.—The Lower Mercer ore is quite steady in Bloom Township, but the Lower Mercer limestone was nowhere observed. The ore was mined by stripping, for use in the charcoal furnaces, and is rather rich in iron, comparing favorably with many Lake ores. It is usually somewhat fossiliferous, but not nearly so much so as the limestone. A few sections will be given so that the member may be traced northward to the Jackson County line. On the land of the Webster Brick Company, in Section 24, the following record was taken:

	Ft.	In.
Ore, *Big Red Block* or *Upper Mercer*	--	4
Covered	8	--
Sandstone	6	--

	Ft.	In.
Ore, *Sand Block*	--	8
Shale and covered	14	--
Coal, *Webster Block* or *Upper Mercer*	1	4
Clay, good	4	6
Shaly sandstone and covered	7	--
Sandstone	7	--
Covered	11	--
Ore, *Little Red Block* or *Lower Mercer*	--	4

A section obtained on the property of S. H. Wiseman and S. G. Huffman, Section 14, is given below:

	Ft.	In.
Coal, *Webster Block* or *Upper Mercer*	1	1
Shale, blue	1	1
Clay shale, dark	1	--
Covered	8	--
Ore, *Little Red Block* or *Lower Mercer*	--	2
Covered	56	--
Coal blossom, *Lower Mercer*	--	6

In Section 2, on the land of Charles Dillon, the following record which shows the positions of the ores, was obtained:

	Ft.	In.
Ore, *Big Red Block* or *Upper Mercer*	--	4
Covered	16	--
Ore, *Sand Block*	--	3
Shale and covered	35	--
Ore, *Lower Mercer*, fossiliferous	--	5

Economic Value

The Little Red Block or Lower Mercer ore was used to a considerable extent and liked very much by the operators of the charcoal furnaces. Under heavy cover it is a blue carbonate, but along the outcrop the ore has weathered to the hydrated oxide forms which were the types most desired for charcoal furnace work. The bed, usually from 2 to 4 inches in thickness, and with a maximum measurement of 8 or 10 inches, is quite persistent when the interval is composed of shales. This ore was extensively mined by stripping in Bloom Township, although it was also worked in Porter, Vernon, and Green townships. The ore was obtained entirely by stripping from along the outcrop where the cover was shallow, and where the ore was oxidized to the ferric state. A partial analysis by the writer, of a sample obtained from near Scioto Furnace, is as follows:

Metallic iron, Fe	42.30
Silica, SiO_2	15.05
Alumina, Al_2O_3	2.20
Phosphorus, P	.265
Manganese, Mn	.34

The quality of the ore thus shown is excellent for foundry iron. Since the advent of the Lake ores, these thin deposits are of little value, but they have an interest in connection with the early history of the iron industry in this State, and may increase in importance in the future.

The Lower Mercer limestone found along Pine Creek, in Vernon Township, is a hard, dense rock, but as the bed is usually thin, and as the better developed Ferriferous limestone is present in the same area, it has no special economic value. It is of interest mainly for stratigraphic work, as the bed has wide areal distribution, extending from Pennsylvania across Ohio into Kentucky, and as the member is easily recognized by its characteristic fossils. The flinty deposit of limestone on this horizon, noted in Green Township, is also quite fossiliferous, and affords good collecting. No analyses were made in order to determine the quality of the limestone in this region, but from general appearances, the components are much the same as those found in the rock in Jackson County.

UPPER MERCER, WEBSTER BLOCK, OR No. 3a COAL AND CLAY

The Upper Mercer coal, with its associated clay, is found in the interval between the Lower and Upper Mercer limestones, or between the Lower and Upper Mercer ores, which in most cases alone represent the Mercer horizons. It lies closer to the Sand Block ore, when this member is present, than to either of the Mercer ores. The bed is quite persistent when the interval is composed largely of shales, but in some localities the coal is completely replaced by a heavy sandstone. The Upper Mercer or Webster Block coal is found only in Bloom, Vernon, and Green townships. Its position with reference to other members is shown in the following sections.

Green Township.—In Green Township the Upper Mercer coal, although usually present, seldom has sufficient thickness to be of much value even for a domestic supply. This bed, however, has fair volume along the Ohio River just east of this township in Hamilton Township, Lawrence County. Just north of the divide, along the tram road that leads from the Ohio Valley to Ohio Furnace, the Upper Mercer coal is mined by drifting for local needs. The following measurements were taken in a mine on the property of the Hanging Rock Iron Company:

	Ft.	In.
Sandstone	4	--
Coal, *Upper Mercer*	1	4
Clay	2	--

In the vicinity of Ohio Furnace this bed is thin, seldom exceeding 1 foot in thickness; further in some places it is of a cannel nature, which usually represents shore stages of deposition. This is the condition of the bed also on the Henry Folsom farm, south of Franklin Furnace, where the following record was secured:

	Ft.	In.
Ore, *Upper Mercer*	--	7
Shale and covered	24	--

	Ft.	In.
Sandstone with parts covered	8	--
Coal, cannel type, *Upper Mercer*, reported thickness	1	6

On the ridges north and east of Franklin and Junior furnaces the Upper Mercer coal is thin, and in many places completely replaced by thick sandstones. The position of the member is shown in the following section, taken on the land of J. D. Willis, about one mile west of Powellsville:

	Ft.	In.
Ore, *Upper Mercer*	--	7
Shale and covered	25	--
Coal blossom, *Upper Mercer*	1	--

Vernon Township.—The Upper Mercer coal is also generally thin in Vernon Township, but in the vicinity of the village of Lyra it expands so that the deposit is mined for a part of the local fuel supply. However, the coal is erratically bedded in this small field and the mining conditions are somewhat unsatisfactory. These features are brought out in more detail by the recorded sections. The position of the Upper Mercer coal with reference to that of other members is illustrated by a record obtained along the road that leads from Poplar Fork to Clinton Ridge, in Section 28. The measurements follow:

	Ft.	In.
Ore, *Upper Mercer*	--	4
Shales and covered	22	--
Coal, *Upper Mercer*	1	--
Sandstone and covered	19	--
Ore, *Lower Mercer*	--	3
Covered	55	--
Coal, *Lower Mercer*	1	8

Along the road that leads from Germany Hollow to the eastern end of Clinton Ridge, in Section 26, the following rocks were exposed for measurement:

	Ft.	In.
Limestone, *Ferriferous*	3	--
Clay and clay-bond sandstone	18	--
Clay shale, with nodules of iron ore	10	--
Ore, nodular	--	6
Clay shale, arenaceous	6	6
Sandstone	18	--
Ore, nodular, irregular	--	6
Sandstone	2	6
Shale, siliceous	18	--
Shale, dark	3	--
Coal blossom, *Tionesta*	2	--
Clay	2	--
Sandstone	--	6
Clay	1	6
Sandstone, shaly	5	--
Coal on *Upper Mercer* ore horizon	1	4

In the vicinity of Lyra the Upper Mercer coal has been mined for many years for local use. The following record was obtained just east of the road in Section 23, on the land of Thomas Patton:

	Ft.	In.
Limestone, *Ferriferous*	4	--
Covered	60	--
Sandstone, massive	55	--
Covered	10	--
Sandstone, massive	20	--
Shale	1	6
Coal, *Webster Block* or *Upper Mercer*	1	6

South of the above locality, near Clinton Furnace, the Upper Mercer coal was mined for use when the furnace was in operation. The bed is reported to be about 2 feet in thickness. In Section 14, on the farm of C. F. Taylor, the Upper Mercer coal has excellent volume, and is regularly mined for a part of the neighborhood supply of fuel. The bed is made up of two coal benches, divided by a parting of bony coal and shale. There are from 6 to 10 inches of draw shale above the coal which must be removed in mining the fuel. Above this shale bed there is a massive sandstone which forms an excellent roof. The record taken here follows:

		Ft.	In.
Coal	*Webster Block* or *Upper Mercer*	2	1
Shale and bone		--	6
Coal		1	5
Clay		2	--
Sandstone		10	--
Shale, sandy		6	--
Shaly sandstone and sandy shale		9	--
Limestone, *Lower Mercer*		1	--

Just east of the village of Lyra the Upper Mercer coal has contributed fuel for local needs for many years, and is known in this locality as the Nagel coal.

West of Lyra the Upper Mercer coal also contributes fuel for domestic needs. Here the deposit is made up of two coal benches separated by a clay parting, which structure is also found in restricted areas south of South Webster in Bloom Township, and west of Hanging Rock in Hamilton Township, Lawrence County. The structure of the bed is shown in the following section taken on the farm of Charles Hayward:

		Ft.	In.
Ore and sandstone, *Sand Block*		--	10
Coal	*Upper Mercer*	--	11
Clay, plastic		1	3
Coal		1	4

In this locality the Upper Mercer coal is also mined on the property of Susan Newland. North and west of this small Lyra field the bed thins to about 1 foot 4 inches in thickness, and is represented only by the upper bench of coal.

Bloom Township.—Although the Upper Mercer coal in Bloom Township is everywhere thin, seldom expanding to 2 feet, it has contributed for over 40 years the main supply of domestic fuel for the village of South Webster and for the adjacent region. The areal extent of this coal in a general way is across the eastern half of the township. In this area the bed is persistent and has excellent mining conditions. In Section 22, on the property of the Webster Brick Company, the record is as follows:

	Ft.	In.
Ore, *Sand Block*	--	8
Shales and covered	14	--
Coal, *Webster Block* or *Upper Mercer*	1	4

In the same section one-half mile south of the above, on the land of John Grant, the lower bench of this member is present, and the associated clays have good ceramic qualities. A record taken in a mine on this property follows:

		Ft.	In.
Coal	*Upper Mercer*	1	3
Clay, good		2	--
Coal		--	8
Clay, plastic, good		4	--

In Section 13, on the land of S. H. Wiseman and S. G. Huffman, this coal is somewhat thin, and is of a cannel nature. The following record is given as it shows the positions of the ore beds with reference to the Upper Mercer coal:

	Ft.	In.
Ore, *Big Red Block*	--	6
Covered	16	--
Ore, *Sand Block*	--	4
Covered	23	--
Sandstone	4	--
Coal, *Webster Block* or *Upper Mercer*	1	1
Shale, blue	1	1
Clay shale, dark	1	--
Covered	7	--
Ore, *Little Red Block*	--	2

In Section 24, on the W. M. Galliger property, the Upper Mercer coal and the Boggs ore have been mined by drifting, and the interval of separation obtained by measurement is given below:

		Ft.	In.
Coal, *Webster Block*		1	4
Covered		54	--
Sandstone		15	--
Shale, dark, tough, fissile		1	3
Ore	*Boggs*	--	4
Shale, blue		--	2
Ore		--	11

North of Bloom Station, on the farm of W. F. Kanoust, the Upper Mercer coal was seen giving way to sandstones. It is represented by thin layers of cannel coal, which is the prevailing type under shore conditions. The section follows:

		Ft.	In.
Coal	*Tionesta*	1	6
Clay		1	--
Coal		--	6
Covered		38	--
Shale		5	--
Ore, *Big Red Block* or *Upper Mercer*		--	2
Shale		1	--
Coal		--	6
Clay		1	--
Sandstone, massive		36	--
Coal, cannel	*Webster Block* or *Upper Mercer*	--	5
Sandstone		--	2
Coal, cannel		--	2

In the two northern tiers of sections in Bloom Township, the Webster Block coal is thin or completely replaced by the massive sandstone found at this horizon. In the isolated hill in the western part of Section 19, the Upper Mercer or Webster Block coal is a true cannel. A section at this place is as follows:

	Ft.	In.
Ore, *Big Red Block* or *Upper Mercer*	--	6
Covered	22	6
Sandstone, massive	16	--
Coal, cannel, *Webster Block* or *Upper Mercer*	2	--

In the eastern part of Section 19, on the land of L. Holenbeck, the Upper Mercer coal is thin, as shown below:

	Ft.	In.
Ore, *Big Red Block* or *Upper Mercer*	--	4
Covered	18	--
Sandstone, massive	17	--
Coal, cannel, *Webster Block* or *Upper Mercer*	--	7

On the Bloom Furnace land in Section 30, just west of the furnace stack, the coal is shown giving way to the sandstone. It is only a few inches in thickness and is of a cannel nature.

Both benches of the Upper Mercer coal, which are separated by about 10 inches of clay, are present on the land of Edward Bowers in Section 24. A record taken at a drift mine here is given below:

		Ft.	In.
Coal	*Webster Block* or *Upper Mercer*	1	--
Shale		--	8
Bone coal		--	2
Coal		--	8
Clay, good		3	--

In Section 23, on the property of William Carmichael, the Upper Mercer coal is regularly mined by drifting for domestic use at South

Webster. Although the bed is thin the coal is of fine quality and of a blocky nature. The record given below was taken at this mine:

	Ft.	In.
Coal, *Upper Mercer*	1	4
Clay, good, plastic	4	--
Covered	10	--
Ore, *Lower Mercer*	--	4

West of this, on the land of John Slack, in Section 22, the measurements taken in a mine are given below:

	Ft.	In.
Coal, *Upper Mercer*	1	6
Clay, good, plastic	3	--

On the land of Smith Hayward, in Section 35, the following strata were exposed for measurement:

	Ft.	In.
Coal, *Tionesta*	2	--
Covered	18	--
Ore, *Big Red Block* or *Upper Mercer*	1	6
Covered	16	--
Ore, *Sand Block*	1	--
Shale	10	--
Coal, *Webster Block* or *Upper Mercer*	1	6

Economic Value of Upper Mercer, Webster Block, or No. 3a Coal

The Upper Mercer coal, which is really important only in parts of Bloom and Vernon townships, in this county, has furnished a considerable part of the local fuel supply for many years. The quantity of coal yet available is large as only a small territory has been worked out. In some localities the bed is composed of one bench only, while at other places it has a lower bench separated from the one above by clay or shale. The quality of the coal in the upper bench is far superior to that in the lower, which is often somewhat bony. The lower bench is thin, seldom reaching 1 foot in thickness, while the upper bench has a maximum thickness of about 2 feet, with an average of about 1 foot 4 inches. The Webster Block or Upper Mercer coal is usually a bituminous variety, with a high volatile content, but in a few localities it changes to a true cannel coal.

The Upper Mercer coal is one of the best domestic coals in the State. It lights easily, burns with a long flame, and has good heating value. The sulphur content is low, the ash small in amount and light colored, and it clinkers only at high temperatures. For domestic use it is considered superior to the Quakertown or Wellston coal.

Although the bed is thin, the coal is mined for 5 cents per bushel, or $1.25 per ton. One man is able to average about 60 bushels per day in regular work. Usually the coal lies in regularly jointed blocks with a soft clay below, in which the cutting is done. The clay is thus picked out and the coal wedged down. In this way practically all the coal is obtained in large lumps, so the loss from fine coal is at a minimum. In some cases the clay below is shot loose, then the coal taken down. The roof is either a tough shale or a sandstone.

Economic Value of Upper Mercer Clay

Below the Upper Mercer coal there is found a deposit of Upper Mercer clay, which is usually from 3 to 5 feet in thickness, and which varies in composition from a quite pure plastic clay to one very siliceous. This clay is of value, as it is well fitted for the manufacture of high-grade face brick and stoneware, or for bonding clay for various purposes. It was formerly mined along with the coal by the Webster Brick Company for the manufacture of building brick. Worked conjunctly, the cost of mining the clay is from 30 to 50 cents per ton, and that of mining the coal is from 50 to 70 cents.

Counting 60 per cent available in mining, the specific gravity of coal 1.3, and that of clay 2.5, the yield per acre for coal, where the bed is 1 foot 4 inches thick, is 1,416 tons (2,000 lbs.), and for the clay, where 4 feet thick, is 8,168 tons. The coal from this thin bed amounts to over one-half the quantity required to manufacture the clay into ware, which under the above specified conditions will produce 2,300,000 building brick. Conjunctly the Upper Mercer coal and clay are an asset worthy of consideration, especially where manufacturing conditions are favorable. Otherwise the coal bed is valuable only for local domestic consumption.

SAND BLOCK ORE

Where present the Sand Block ore is found in the interval between the Upper Mercer coal and the Upper Mercer limestone or Big Red Block ore. In some places the ore lies close to the coal, while at other places it may be found as much as 30 feet above. The average interval is about 15 feet. The relation of this ore to members both below and above is shown in many of the preceding sections; hence its stratigraphy will not be considered further here. This deposit, found in Bloom, Vernon, and Green townships, contributed some ore for the old charcoal furnaces that formerly existed in the region. The bed averages from 4 to 6 inches in thickness and has a maximum measurement of about 12 inches. Under heavy cover it is a siliceous blue carbonate, but along the outcrop this has weathered to the hydrated oxides. The deposit is too thin and the ore too lean to be of any special importance at present.

UPPER MERCER LIMESTONE HORIZON

The Upper Mercer limestone is seldom present in Scioto County, but the horizon is quite constantly marked by an iron ore which is known as the Upper Mercer, Big Red Block, or Franklin. It was the main reliance of Franklin Furnace, and was extensively used also at Junior and Ohio furnaces. Further, it was used but to a more limited extent by Scioto, Empire, Clinton, Howard, and Bloom furnaces. The Upper Mercer ore is found in Green, Vernon, and eastern Bloom townships. Also on this horizon there is found in some localities a coal bed which nowhere expands to any considerable thickness, but which has yielded a small quantity of domestic fuel. The average interval between the Lower Mercer ore and the Upper Mercer ore is approximately 52 feet. It is about 30 feet above the Upper Mercer or Webster Block coal and approximately 35 feet below the Tionesta coal. The mean interval from the Upper Mercer ore to the Ferriferous ore is nearly 110 feet. The positions of various members with reference to those of the Upper Mercer beds will be brought out in more detail in the general stratigraphy and in the discussion under the township headings.

Green Township.—The Upper Mercer ore is much better developed in Green Township than it is in either Vernon or Bloom, although in these it often has good volume for a coal formation ore. This ore was regularly mined for many years by drifting at Ohio Furnace by the Hanging Rock Iron Company, although at present the mines are abandoned, owing to the influence of the more available and somewhat richer Lake ores. A section taken at the mines of the above mentioned company, located north of Ohio Furnace, is given below:

		Ft.	In.
Shale		2	--
Ore, upper block	*Upper Mercer*	--	7
Parting		--	--
Ore, lower block		--	11
Coal, dense, hard		--	2

The Upper Mercer ore in this locality is sparingly fossiliferous and the lower part of the bed is quite calcareous also, often approaching limestone in composition, and in fact the rock should be called a ferruginous limestone. On the river hills, south of Ohio Furnace, John Norris reports that the Upper Mercer ore is only from 4 to 5 inches in thickness and is unsteady. This is the condition of the ore where noted in the hills south of Junior Furnace. North of this place, however, the ore has good volume and continuity, and is reported to vary in thickness from 6 inches to 1 foot 8 inches.

The Upper Mercer ore is present only on the high knobs on the main ridges from Franklin Furnace north to Pine Creek. From observations and reports the usual thickness of the bed is from 6 to 10 inches. This ore has been mined rather extensively by stripping along Tick Ridge, where it is stated to have excellent volume for a coal formation ore. On the north end of Tick Ridge, on the property of J. D. Willis, the following measurements were obtained:

	Ft.	In.
Ore, *Upper Mercer*	--	7
Covered	25	--
Coal blossom, *Upper Mercer*	1	--

Vernon Township.—Although the Upper Mercer ore is represented in most of Vernon Township, it is best developed in local areas along Pine Creek, in the eastern part. Next to the Ferriferous ore it was the main reliance for the ore supply of the charcoal furnaces, Empire, Clinton, and Howard. The Upper Mercer limestone was not observed in this township. The interval from the Upper Mercer ore to other members is shown in the following record, obtained along the road that leads from Poplar Fork to Clinton Ridge, in Section 28:

	Ft.	In.
Limestone, *Ferriferous*	2	--
Sandstone and covered	54	--
Coal blossom, *Tionesta*	1	--
Shales and covered	32	--
Ore, *Upper Mercer*	--	4
Shales and covered	22	--
Coal, *Upper Mercer*	1	--

The Upper Mercer ore has excellent volume on the land of T. Kern, and on the adjoining properties in Section 23. The ore is reported to have a thickness varying from 1 to 3 feet, and it was formerly mined by drifting. The Upper Mercer ore was also mined north of the village of Lyra, along Pine Creek, but the bed is much thinner and quite unsteady.

Bloom Township.—The Upper Mercer ore is somewhat persistent in the eastern part of Bloom Township, but the limestone is not well represented. The normal volume of the ore is from 6 to 10 inches although at a few places it expands to as much as 1 foot 6 inches. This ore was well liked by the charcoal furnace operators, as it made a good grade of foundry iron; hence it was mined by benching quite extensively. The only place in Bloom Township that the Upper Mercer limestone was observed was at the foot of the incline of the Morgan and Horton mines, in Section 5, where the following composite section was measured:

	Ft.	In.
Limestone, *Ferriferous*	8	--
Coal and clod, *Clarion*	4	--
Covered	51	--
Sandstone, shaly	5	--
Shale, black	5	--
Coal, somewhat bony, reported thickness } *Tionesta*	1	6
Coal, good, reported thickness	1	6
Covered	4	--
Sandstone, massive	35	--
Covered	4	6
Ore, *Big Red Block* or *Upper Mercer*	--	5
Limestone, *Upper Mercer*	--	8

In Section 30, just west of the old Bloom Furnace stack, the record is as given below:

	Ft.	In.
Coal blossom, *Tionesta*	1	--
Clay	2	--

	Ft.	In.
Shale	4	--
Sandstone	3	--
Shale	12	--
Covered	10	--
Ore, *Big Red Block*	--	6

On the land of Smith Hayward, in Section 35, the Upper Mercer ore has good thickness, and is sparingly fossiliferous. The ore and other members were well exposed; hence the following measurements were obtained:

	Ft.	In.
Coal, *Tionesta*	2	--
Covered	18	--
Ore, *Big Red Block* or *Upper Mercer*	1	6
Covered	16	--
Ore, *Sand Block*	1	--
Shales	10	--
Coal, *Webster Block* or *Upper Mercer*	1	6

In Section 26, on the John Poetker land, the Upper Mercer ore has good volume, as is shown in the record given below:

		Ft.	In.
Ore, kidney, red	*Upper Mercer*	--	6
Ore, siliceous, gray		1	8

Economic Value

The coal found at the Upper Mercer horizon is of good quality, but, as the bed is thin, it is mined by stripping only in the creek beds and under shallow cover along the outcrop. It has no practical value at present. The Upper Mercer limestone, where found, is thin and usually very siliceous. It is important only for its stratigraphic value as it is a good bench mark which aids in determining the position of other members. Next to the Ferriferous, the Big Red Block, or Upper Mercer ore was the most important deposit worked for the old charcoal furnaces during their period of activity. In fact, it was the main source of ore for most of the furnaces west of the limestone district, and even there it furnished a considerable part of the supply. It has also been used by the modern furnaces to some extent. The Hanging Rock Iron Company mined this ore for many years, near Ohio Furnace, in Scioto County, but it abandoned the mines in 1912.

In many places on the Upper Mercer horizon there are two ore benches which differ in quality and in physical appearance. The upper bench, usually thin, is much richer in iron than the lower bench, which often has excellent volume. The following analyses made by the writer, are used through the courtesy of the Columbus Iron and Steel Company. The partial analyses of Upper Mercer ore from the outcrop on the John Poetker land, are as given below:

	No. 1	No. 2
Iron, Fe	48.60	24.95
Siliceous material	14.95	46.10

Sample No. 1—Analysis of upper 6 inches of deposit.
Sample No. 2—Analysis of entire 2 feet 2 inches of ore.

The Upper Mercer ore, which was formerly mined by drifting, on the Kern and McCallister properties, near Cornwall, south of Lyra, gave the following results:

	No. 3	No. 4
Iron, Fe	42.35	28.40
Silica, SiO_2	21.15	38.35
Lime, CaO	trace	
Magnesia, MgO	trace	
Manganese, Mn	.63	
Phosphorus, P	.203	
Ignition loss	11.60	

Sample No. 3—Average sample of bed. Theodore Kern property, near Cornwall Station, Vernon Township.

Sample No. 4—Sample from outcrop. McCallister property. Same locality as that of No. 3.

An analysis of the deposit, 1 foot 6 inches in thickness, from the Smith Hayward land follows:

Iron, Fe	34.65
Silica, SiO_2	15.90
Alumina, Al_2O_3	3.34
Phosphorus, P	.219
Manganese, Mn	.57
Lime, CaO	2.05
Magnesia, MgO	1.48
Zinc, Zn	trace
Ignition loss	24.90

The above sample, which was taken from an entry, and thus under good cover, well represents the average composition of the ore. The Upper Mercer ore makes a good grade of foundry iron, and this fact is well illustrated by the superior quality of the old charcoal iron. The usual quality of the ore compares favorably with the siliceous Lake ores, and, where the mining conditions are good, it should be utilized. The ordinary method of comparing the value of Lake ores with these high volatile or carbonate ores is such that the latter are reduced below their true value. If the actual worth of these are obtained, they can be mined at a profit, especially where the deposit has good volume.

TIONESTA, OR No. 3b COAL AND CLAY

Stratigraphy and Extent

The interval from the Tionesta coal to the overlying Ferriferous limestone varies from 50 to 90 feet, but averages about 70 feet, while the interval from this coal to the Upper Mercer ore, which lies below, varies from 20 to 55 feet, but averages about 35 feet. The bed, unless replaced by heavy sandstones, is quite persistent, although in places it is thin or bony. Black carbonaceous shales, and in places a fossiliferous sandstone above the coal, are aids in identifying the horizon. The coal is found well above drainage in the eastern parts of Bloom, Vernon, and Green townships. It is of most importance in the vicinity of Empire Furnace, in Vernon Township, where it is regularly mined for a part of the local fuel supply.

Green Township.—The Tionesta coal is found well towards the summits of the main ridges in the eastern half of Green Township, but the bed in a part of this area is replaced by massive sandstones, or it is thin and bony. In a few places, however, the member thickens so that it may furnish a small supply of domestic fuel when the more available Lower Kittanning coal found east of this in Lawrence County is exhausted. On the divide along the road that leads from Ohio Furnace to Pine Creek the Tionesta coal was well exposed for measurement. The record secured follows:

		Ft.	In.
Ore, *Ferriferous*		--	10
Sandstone and covered		78	--
Sandstone, shaly		10	--
Sandstone		2	--
Coal	*Tionesta*	1	2
Coal, bony		--	7
Coal		--	2

At places in this locality the bed is reported to expand so that the good coal has a thickness of 1 foot 8 inches. On the Ohio River hills south of Ohio Furnace the Tionesta coal is thin, or replaced by thick sandstones, and from outcrop indications the member is poorly represented on the hills north of Junior Furnace.

Vernon Township.—The best field of Tionesta coal in Scioto County is in Vernon Township, in the vicinity of Empire Furnace, and on Clinton Ridge, north of this where the bed is regularly mined by drifting. The coal, however, is somewhat uncertain in character and in extent, as the massive overlying sandstone often modifies or replaces it. The fuel is generally of good quality for domestic purposes. East of Empire Furnace on the property of Fred Smith, in Section 33, the Tionesta coal is regularly mined by drifting. The record obtained at this place follows:

		Ft.	In.
Shale, tough, dark		12	--
Coal	*Tionesta*	--	9
Coal, bony		--	1
Coal		1	--
Clay		--	6
Coal		--	6

This bed is also mined on the land of G. Knapp, and to a less extent on adjoining properties. On this ridge the member is reported to be made up of two main coal benches as shown above, while on the adjoining ridges it is said to consist of only the upper coal stratum. On Clinton Ridge, at the head of Lick Run, the Tionesta coal is also regularly mined. The structure of the bed in this locality is shown by the following section obtained on the land of Isaac Bennington, in Section 21:

		Ft.	In.
Shale		10	--
Coal		1	1
Clay	*Tionesta*	1	6
Coal		--	6

On Clinton Ridge east of this, on the property of Elias Weaver, in Section 22, only the upper bench of the Tionesta coal is present. The following record shows the structure of the bed at this place:

		Ft.	In.
Shale		3	--
Coal, bony	*Tionesta*	--	2
Coal, good		1	1
Clay, siliceous		2	--

Along Pine Creek the Tionesta coal is generally thin, and has been mined but little even for house use. Its position is shown in the following record made about one mile north of Clinton Furnace:

	Ft.	In.
Ore, *Ferriferous*	--	8
Sandstone and covered	59	--
Coal blossom, *Tionesta*	1	--
Clay shale, siliceous	10	--
Covered	10	--
Sandstone, massive	43	--
Covered	15	--
Shale	2	--
Coal blossom	--	2
Clay	2	--
Ore, *Sand Block*	--	4
Shale and covered	11	6
Shale, black	1	--
Coal blossom, *Upper Mercer*	1	6
Clay	6	4
Shale	3	8
Coal stain	--	1
Clay shale	1	--
Sandstone, shaly	8	--
Covered	7	--
Limestone, arenaceous, *Lower Mercer*	1	--
Shale	6	4
Sandstone	2	--
Shale	3	--
Shale and covered	10	--
Coal blossom, *Lower Mercer*	1	--

East of the village of Lyra the Tionesta coal is mined by drifting in a small way on the Yates property, where the measurements given below were obtained:

	Ft.	In.
Limestone, *Ferriferous*	4	--
Sandstone and covered	65	--

	Ft.	In.
Sandstone	20	--
Coal, *Tionesta*	2	2

Bloom Township.—The Tionesta coal extends from Vernon Township across Bloom into Jackson County, where at Monroe Furnace the deposit has excellent volume, and where it was formerly mined for railroad shipment. The bed, although generally thin in Bloom Township, furnishes a small supply of domestic coal which is of good quality. The coal areas are confined to the eastern half of the township. A record taken at the mine of Morgan & Horton, in Section 5, shows the position of the Tionesta coal with reference to that of other well known beds:

		Ft.	In.
Limestone, *Ferriferous*		8	--
Coal and partings, *Clarion*		4	--
Covered		51	--
Sandstone, shaly		5	--
Shale, black		5	--
Coal, somewhat bony	*Tionesta*, reported	1	6
Coal, good		1	6

In Section 18, on the land of W. F. Kanoust, the Tionesta coal has been worked some for local use. A section is as follows:

		Ft.	In.
Shale, dark		5	--
Coal, good	*Tionesta*	1	6
Clay		1	--
Coal, good		--	6

The outcrops of the Tionesta coal and the associated black shales were seen in many places along the main ridge and spurs in the northern part of Bloom Township in sections 1, 2, 11, 12, and 13. On Brady Run, in Lawrence County, just over the line, this coal has been mined for local use, and often has good volume. In the eastern part of Section 19, on the land of L. Holenbeck, where the Tionesta coal is mined by drifting, the measurements of the rocks show the following relations:

	Ft.	In.
Limestone, *Ferriferous*	6	--
Coal, *Clarion*	4	--
Covered	15	--
Coal blossom, *Brookville*	1	--
Covered	38	--
Coal, reported thickness, *Tionesta*	2	--
Covered	40	--
Ore, *Big Red Block*	--	4
Covered.		

In Section 30, near Bloom Furnace, this coal has been mined for local use. In the eastern part of Section 29 the Tionesta coal has been worked on the Frank Holmes property. The banks have fallen in, but the thickness of the bed is reported to be the same as that found in Hawkins Hollow, just across the line in Lawrence County, a section of which follows:

		Ft.	In.
Coal, good	*Tionesta*	--	6
Clay, dark, plastic, good		--	7
Clay, light, plastic, good		1	2
Coal, good		1	1

The coal, 2 feet thick, has been mined on the D. T. Holcomb land, in the southern part of Section 36. In Section 35, on the property of Smith Hayward, the Tionesta coal is mined by drifting.

Economic Value

The Tionesta coal, which is of workable thickness in local areas of the eastern halves of Bloom, Vernon, and Green townships, is variable both in thickness and in structure. The maximum thickness of this coal in Scioto County is about 3 feet, but the average measurement is about 1 foot 6 inches. In some localities only one coal bench is represented, while in others two or three benches, separated by clay or shale partings, are found. The tough shale above the coal forms an excellent roof which aids materially in mining. The quality of the coal in the lower bench is very good, while the quality of that in the upper benches is usually poor. It is a high volatile, free-burning coal, with a moderate amount of ash and sulphur, and has furnished a part of the local supply for many years. Most of the mining done has been by short entries, thus leaving the main bodies of coal in the hills. The main value of this bed is for present and future local domestic needs. At no place in the county is the character of the deposit such as to justify mining on a large scale for the coal alone. In many places the clay below the Tionesta coal has good thickness, and, although usually siliceous, it is low in fluxes; hence well suited for many ceramic purposes. This clay at present is not regularly worked in Scioto County. For economic reasons both coal and clay should be utilized.

ALLEGHENY FORMATION

Rocks belonging to the Allegheny formation are found well above drainage in a narrow belt extending across the eastern part of Scioto County from the Ohio River to Jackson County. Dipping eastward they disappear in the central part of Lawrence County. Only the lower part of this important division of rocks is found in the area under consideration. The interval embraced is that beginning with the Brookville coal, which is the basal member, and ending with the Middle Kittanning coal, only decayed remnants of which are found on a few of the highest knobs in eastern Bloom and Vernon townships. The rocks represented are sandstones, clays, coals, iron ores, shales, and limestone. As a whole the formation in Scioto County is of no great importance as the areas of valuable strata are small. The members will be taken up in order beginning with the oldest.

BROOKVILLE OR No. 4 COAL

The Brookville coal is wanting in most of the territory, as it is replaced by heavy sandstone. When present, the bed is thin, seldom reaching 1 foot in thickness, and is usually found about 20 feet below the Ferriferous limestone. The Brookville coal is shown in the following record taken in the eastern part of Section 19, Bloom Township, on the land of L. Holenbeck:

	Ft.	In.
Coal, *Clarion*	4	--
Covered	15	--
Coal blossom, *Brookville*	1	--
Covered	38	--
Coal, *Tionesta*, reported thickness	2	--

A few inches of coal are found on the Brookville horizon at other places in Bloom Township. This member in Vernon and Green townships is occasionally represented by thin lenses of coal in sandstone, or by dark bony shales with thin coal bands. In Scioto County the Brookville coal has no value worthy of consideration aside from its stratigraphic relations.

CLARION OR HECLA SANDSTONE

A sandstone which is found below the Clarion coal or clay in massive beds, and which was formerly used for hearthstones by the charcoal furnaces, is designated Hecla sandstone in former reports. This type sandstone lies just below the Clarion clay. It is rather coarse-grained, low in iron compounds, and has a clay for the bonding material. It is an excellent ganister, as its refractory qualities were thoroughly tested by the charcoal furnaces. The Clarion sandstone is found only on the high hills and ridges in the eastern part of Scioto County, and at present it is not utilized except for minor purposes.

CANARY ORE

The Canary iron ore is found from 25 to 30 feet below the Ferriferous limestone, but the bed is quite unsteady, being developed only in restricted areas. In Scioto County it is best developed on Clinton Ridge in Vernon Township, where this ore was formerly mined in a small way for the charcoal furnaces. The bed extends along the ridge from Pine Creek to the Cadot Hill in Section 22. The Canary ore is also present at a few places near the summits of the main ridges in the eastern part of Green Township, but it was not observed in eastern Bloom as the horizon is taken by massive sandstones. The interval from the Canary ore to the Ferriferous limestone is shown in the following section, taken on Clinton Ridge near the head of Germany Hollow, in Section 26, Vernon Township:

	Ft.	In.
Limestone, *Ferriferous*	3	--
Clay and clay-bond sandstone	18	--

	Ft.	In.
Clay shale, with scattered ore nodules	10	--
Ore, *Canary*	--	6

The Canary is a concretionary ore of the carbonate variety, and is usually siliceous in character. It has no special value at present, although it contributed in a small way to the ore supply of the charcoal furnaces that operated in eastern Scioto County.

FERRIFEROUS ORE, VANPORT OR FERRIFEROUS LIMESTONE, AND CLARION COAL AND CLAY

These important members of the Allegheny formation are poorly represented in Scioto County, as they are found only on the high knobs and ridges in the eastern parts of Bloom, Vernon, and Green townships. Owing to the shallow covering and to the disappearance of the bed in its extension southward, the Clarion coal has normal development only in small areas in northern Bloom Township and in the extreme eastern part of Vernon. The Ferriferous limestone, which extends with some wants across eastern Scioto County from Jackson County on the north to the Ohio River on the south, is generally thin and often flinty. However, in local areas in northern Bloom Township this member is present in force. The Ferriferous ore has better continuity, and has about the same volume throughout its extent. As these members are so closely associated general sections showing their stratigraphy and extent will be given instead of considering each bed separately.

Bloom Township.—The Clarion coal and the Ferriferous ore and limestone in Bloom Township are confined to small areas on the main ridges in sections 1, 5, 6, 7, 8, 19, 20, 25, 29, 30, 31, 32, 36, and sections 5 and 6 south. The most important area is that west of Eifort where the members all have normal volume. The strata exposed at the mines of Morgan & Horton, west of Eifort, in Section 5, show about the average thicknesses and relations of the various members when normally developed. The measurements follow:

		Ft.	In.
Ore, *Ferriferous*		--	5
Limestone, *Ferriferous*		8	--
Shale, draw slate		--	4
Coal	*Clarion*	1	--
Clay		--	4
Coal		1	7
Clay, impure		--	1
Coal		--	5
Clay		2	--

The structure of the deposits in sections 1 and 6 is practically the same as the above. The small pockets of limestone and coal on this horizon, found in the high knobs in the southeastern part of Bloom Township, have been worked to a small extent, but the strata were not favorably exposed for measurement. The Clarion coal, however, in most of this area is thin or decayed, while the limestone is usually very flinty in character.

Vernon Township.—In Vernon Township the Ferriferous limestone with its associated ore, and the Clarion coal and clay are found on all the high ridges east of Pine Creek, but west of this stream the beds are present only along the main hill and spurs of what is known as Clinton Ridge as far west and north as the western part of Section 22. The Clarion coal is not well developed, however, in the areas south of Howard Run and east of Pine Creek, or in those on Clinton Ridge, while the Ferriferous limestone thins or becomes patchy in its extension southward and westward. The Ferriferous ore is far more persistent than the limestone, but it is often completely replaced by massive sandstones. The beds have only local value. In Section 1 the Clarion coal, which is mined for local use, and the Ferriferous limestone and ore have about their normal volume. The following record was obtained from an outcrop exposure:

	Ft.	In.
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*	8	--
Coal, *Clarion*, on outcrop	3	--

On Clinton Ridge the Ferriferous limestone is stated to vary from 2 to 7 feet in thickness, while the Clarion coal is reported to be of no value, as it is thin and rotten. The Ferriferous ore is quite steady, and was formerly mined along the entire ridge. The thickness of the ore varies from a few inches to about 1 foot. The Clarion clay has good volume but is siliceous in character.

Green Township.—In Green Township the horizon of the Clarion coal, Clarion clay, Ferriferous limestone, and Ferriferous ore extends westward on the main ridge to about one mile west of Ohio Furnace. The Clarion coal is marked only by a smut streak, but the Clarion clay, although quite siliceous in character, is from 2 to 5 feet in thickness. The Ferriferous limestone is traced by scattered lenses of flinty or cherty material. The most constant of these members by far is the Ferriferous ore, which varies in thickness from 3 inches to about 1 foot 6 inches, and which was mined by stripping along its entire outcrop during the days of the charcoal furnaces.

Economic Value of Clarion Clay

The total area of Clarion clay in Scioto County is relatively small, and as the deposits are usually widely scattered, and as the clay is siliceous in character, although low in fluxes, it has no value worthy of special consideration. At present the Clarion clay has not been utilized in this county for commercial purposes.

Economic Value of Clarion Coal

Owing to the position of the Clarion coal near the summits of the main ridges in the eastern part of Scioto County the area of the field is small, and owing to the shallow cover and to the absence of the coal in its extension southward only a part of this area is productive. The area in which the coal may be mined will not exceed 3 square miles. The Clarion coal at present is mined for railroad shipment at only one place in the county, which is near Eifort Station, in Bloom Township, but formerly it was also worked by other companies in this region. Near Eifort Station, Morgan & Horton mine the Clarion coal with the overlying Ferriferous limestone and Lower Kittanning clay for railroad shipment. The character of the coal is shown by the following analysis:[1]

Mine of Morgan and Horton, Eifort Station, Bloom Township, Scioto County. Coal has ample cover. Sampled in August, 1901, by Professor Edward Orton, Jr.

Chemical analysis and calorific value of sample

Ultimate		*Proximate*	
Carbon	65.30	Moisture	6.80
Hydrogen	5.33	Volatile matter	37.92
Oxygen	15.35	Fixed carbon	45.94
Nitrogen	1.23	Ash	9.34
Sulphur	3.45		
Ash	9.34		

Calorific value { 6,577 calories.
11,839 B. t. u.

In Scioto County the Clarion coal is important mainly for a local supply, as the acreage in the isolated tracts is too small to justify large operations.

Economic Value of the Ferriferous Limestone

The Ferriferous limestone was first utilized for flux stone for the old charcoal furnaces that existed in the eastern part of the county. At present it is used principally for flux stone and road ballast. The chemical properties of the stone are such that it is well suited for furnace flux, cement manufacture, or agricultural lime, while the physical properties make it a valuable road material. The quality is shown by the analyses of three cars of stone from the mines of Morgan & Horton, furnished by the Buckeye Steel Casting Company, Columbus, Ohio. Analyst, Downs Schaaf.

	Sample No. 1	Sample No. 2	Sample No. 3
Silica, SiO_2	1.20	1.20	1.20
Alumina, Al_2O_3 Ferric oxide, Fe_2O_3	1.04	1.00	1.10
Calcium carbonate, $CaCO_3$	94.43	95.23	94.13
Magnesium carbonate, $MgCO_3$	3.33	2.57	3.37
Sulphur, S	.450	.167	.257

Phosphorus, P, not determined.

The phosphorus in the Ferriferous limestone averages about .093 per cent.

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[1] Geol. Surv. of Ohio, Bull. 9, pp. 179-180.

Morgan & Horton, of Eifort Station, is the only firm in Scioto County regularly mining and marketing this limestone. It is mined by surface stripping and also by underground working. Compressed air is used for drilling. The stone is sold in the lump form. In Scioto County this limestone is used extensively for road building, but only a part of the supply is local as most of it comes from mines in Washington Township, Lawrence County.

Economic Value of Ferriferous or Limestone Ore

The Ferriferous ore was highly prized by the charcoal furnace operators, as it gave a good yield and as it made foundry iron of the very best quality. The most successful furnaces were those in this ore belt. The area of ore in Scioto County is small as the bed is confined to isolated tracts near the summits of the hills and ridges in the eastern parts of Bloom, Vernon, and Green townships. The quality of the ore has been fully described in the report on Lawrence County; hence the subject will not be considered here.

LOWER KITTANNING COAL AND CLAY

In Scioto County the Lower Kittanning members are best represented in the northeast corner of Bloom Township, where they occur near the summits of the main ridges. Isolated tracts are also found in the southwestern part of this township east of Hales Creek. In Vernon Township the Lower Kittanning deposits are confined to the summits of the high hills east of Pine Creek, and to a few isolated knobs on Clinton Ridge. In Green Township these beds are present in small areas on the main hills east of Ohio Furnace. This is the only locality in Scioto County in which the Lower Kittanning coal is regularly mined for local use. The following section, taken at a mine on the land of the Hanging Rock Iron Company, shows that both coal and clay have the normal development characteristic of these members in the Newcastle field in Lawrence County:

		Ft.	In.
Coal	*Lower Kittanning*	1	3
Coal, bony		--	1½
Coal		1	--
Clay		--	1½
Coal		--	10
Clay, plastic, good, *Lower Kittanning*		12	--

On the Ohio River hills near the eastern edge of Green Township, on the land of Joseph Andre, the Lower Kittanning coal has been prospected, but the coal is badly decayed. The section taken at this place is as follows:

	Ft.	In.
Sandstone	15	--
Coal, *Lower Kittanning*, rotten	1	--
Clay, plastic, *Lower Kittanning*	6	--

In Vernon and Bloom townships this coal is so thin, or so badly weathered, that it has no fuel value. The clay is of good quality, but the amount available in any particular locality is seldom sufficient for working in a large way. It is regularly mined at one place only in the county, viz.: Section 5, Bloom Township, where the clay is mined by stripping by Morgan & Horton. A section of their mine is as follows:

		Ft.	In.
Clay, part flint, dark, *Oak Hill*, not used		2	--
Coal, rotten	*Lower Kittanning*	--	6
Clay		--	1
Coal, rotten		--	5
Clay, irony, not used	*Lower Kittanning*	2	--
Clay, light, plastic, good, used		8	--

The 8 feet of clay worked is of excellent quality, and it goes on the market in good condition, as care is used in mining to keep it free from foreign or impure materials. The clay is sold in the lump or in the crushed form. The clay is ground in a 9-foot dry pan and is then screened to remove the coarser materials.

OAK HILL CLAY

The Oak Hill clay is present in eastern Scioto County, but is of no importance as the area is small, the stratum thin, and the clay poor in quality. Its position is just above the Lower Kittanning coal.

RED KIDNEY ORE

The Red Kidney ore was found on a few high hills in the northeastern and southeastern parts of Bloom Township only. In some places it is only a few feet above the Lower Kittanning coal, but as a general thing it is from 10 to 15 feet above this member. The usual relation is shown by the following measurement taken in Section 5:

	Ft.	In.
Ore, *Red Kidney*	--	3
Shale and covered	11	--
Clay, part flint, *Oak Hill*	2	--
Coal blossom, *Lower Kittanning*	1	--

This ore was worked to a very small extent for the charcoal furnaces, but it is of no importance at present.

MIDDLE KITTANNING, OR No. 6 COAL

The weathered outcrop of the Middle Kittanning coal may be seen in a few places only in eastern Bloom Township, but it has no interest except for its stratigraphic relations.

Important Horizons for Organic Remains

The rocks of the Mississippian and lower Pennsylvanian systems show that well organized life flourished during the whole time interval for the strata everywhere are at least sparingly fossiliferous. During Cuyahoga, Logan, and Maxville time the conditions were favorable for the preservation of animal life that thrived on the muddy floors of the seas, while during Pottsville and Allegheny time the conditions were conducive for the fossilization of plant life that grew luxuriantly on the land and in the shallow waters. The rocks of each formation, however, contain remains of both plant and animal life. There are a number of fossil horizons in the rock strata of Scioto County, some of which are worthy of attention. Those of special interest are listed below.

Cuyahoga Shales and Sandstones.—A locality of exceptional importance is the rock bar along the Ohio River just east of the mouth of the Little Scioto. The fossils are found in the ferruginous concretions in the shales, and in the sandstones also.

Logan Shales and Sandstones.—The shales and sandstones of this formation are usually fossil bearing, but the horizons at which they occur most abundantly are in the Allensville member. Good collecting is found at this horizon in an old road formerly used for hauling clay from the Daum property, located in the southeastern part of Section 33, Harrison Township. The clay road joins the Harrisonville pike in the narrows along the Little Scioto, one and one-half miles from Sciotoville. The ore layer, from 2 to 6 inches in thickness, is made up largely of marine fossils, and is found about 80 feet below the horizon of the Sciotoville clay. Near this, just below the bend in the clay road that leads to Munn Hill, the sandstones on the horizon of the Allensville conglomerate contain many well preserved fossils. The ore above the Allensville conglomerate is also exposed along the road near the home of John Oberly, in Section 2, Harrison Township. This horizon was again observed along the roadside in the central part of Section 11. The fossiliferous ore occurs about 20 feet above the Allensville conglomerate, a good exposure of which is seen near the foot of the hill. Many fossils were noticed at the horizon of the Allensville conglomerate, which, on land of Samuel Shoemaker, in Section 26, Madison Township, is exposed in the stream bed just north of the Portsmouth-Jackson pike.

Maxville Limestone.—The deposits of Maxville limestone found in a few localities on the main ridges in Clay Township north of Portsmouth, and on Woods Ridge in Harrison, are sparingly fossiliferous. In a pile of cherty limestone which was taken from a mine south of the Woods house a few types may be obtained. The limestone which was taken from the Harper shaft in Section 32, Bloom Township, and piled nearby, also contains fossils. They were best represented in the thin shaly partings that separated the limestone layers, but this material at present is completely disintegrated.

Harrison Ore.—A few fossils were found in the Harrison ore, which is exposed at the forks of the road on the Niner Hill, in Section 20, Harrison Township. The cherty material which was derived from the erosion of the Maxville limestone, and which is found in the conglomerate ore that occurs on the zone of contact of Mississippian and Pennsylvanian rocks, also contains imperfect remains of marine life. This material is exposed near the summits of the main ridges in many localities in Clay and Jefferson townships, and at a few places in western Harrison and Madison.

Sharon Conglomerate.—In the sandy layers of the Sharon conglomerate in eastern Harrison and Madison townships well preserved trunks and stems of Coal Measure plants were seen and in a few places observed even in the pebbly layers.

Sharon Coal Horizon.—As would be expected, plant remains are common on this horizon, especially in the regions where the coal is well developed. Many root markings are present in the clays below the coal, while in the shales above the impressions of plant trunks and stems are common. The leaves are not usually well preserved. The shales directly above the Sharon coal at a mine on land of John Alexander, in Section 15, Madison Township, contain many *Lingulae* in a good state of preservation.

Sharon Ore.—The Sharon ore on the land of Joseph Jenkins, on Lick Run, in Section 14, Porter Township, is very fossiliferous, and the remains are well preserved.

Sciotoville Clay Horizon.—The clay contains impressions of roots of Coal Measure plants, but no evidence of animal life was found. The shales and shaly sandstones above the clay in many localities in Scioto and Jackson counties contain fossil *Conostichus* and *Asterophycus* in large numbers. A few places for collecting are: The clay mine on Daum Hill, Section 33, Harrison Township; on land of Dr. Keyes, in Section 28; along the cut of the Baltimore & Ohio Southwestern Railroad near Gephart; and on the point just north of the plant of the Buckeye Fire Brick & Clay Co., Scioto Furnace. At the last named locality worm tracks are also found in the shaly sandstone.

Guinea Fowl Ore.—Well preserved impressions of leaves and stems of Coal Measure plants were found in an exposure of this ore seen along the roadside north of the home of Sampson Spriggs, in Section 10, Madison Township. No remains of animal life were seen in this member.

Quakertown Coal Horizon.—The shales above this coal on land of Henry Moore, near Scioto Furnace, contain scattered imprints of plant life.

Bear Run Coal Horizon.—On this horizon both plant and animal life are represented. On land of H. H. Stevenson, near the forks of the road in the northern part of Section 3, Bloom Township, the shales directly above the coal contain many fossils of *Lingula* in a good state of preservation. At the mines of this coal in the Dever Valley in Jackson County the same fossils were seen also. Plant fossils are present on this horizon, but seldom well preserved.

Lincoln Ore.—The deposits of Lincoln ore north of Scioto Furnace contain plant fossils.

Vandusen Coal Horizon.—In Scioto County the shales above this coal contain some plant remains, but in some localities in Jackson County these shales are highly fossiliferous, and the delicate tracings of the plant tissues are minutely preserved.

Boggs Ore.—The Boggs ore is sparingly fossiliferous. A few marine fossils were seen in the deposit which lies near the head of the hollow south of the home of Charles Dillon, in Section 2, Bloom Township.

Lower Mercer Limestone.—The Lower Mercer Limestone, outcropping along Pine Creek south of Lyra, in Vernon Township, contains the marine fossils characteristic of the member found farther north. Fossils are also present in the flinty material that represents this limestone, and is exposed near the summit of the hill that leads from Haverhill to Ohio Furnace, in Green Township.

Lower Mercer or Little Red Block Ore.—This ore wherever found usually contains fossils which are characteristic of the Lower Mercer limestone. The ore is easily found in the vicinity of Scioto Furnace, or of South Webster.

Upper Mercer or Webster Block Coal Horizon.—Plant fossils are found on the horizon of this coal at the mines south of South Webster.

Sand Block Ore.—This ore is sparingly fossiliferous, and the types found are those common to the two Mercer limestones. The stratum is found in the eastern part of the county in a number of localities, one of which is in the hills south of South Webster, and another is on land of Smith Hayward, in Section 35, Bloom Township.

Upper Mercer Limestone.—This fossil-bearing limestone was seen at the foot of the Morgan & Horton incline, in Section 5, Bloom Township.

Upper Mercer or Big Red Block Ore.—This member, wherever found, contains a few scattered fossils. The ore is quite persistent in the eastern part of the county, and was worked from the Jackson County line to the Ohio River. At present a number of specimens may be collected from the pile of ore at the mouth of a mine on land of Smith Hayward, in Section 35, Bloom Township. Another favorable locality is at the ore mines of the Hanging Rock Iron Company near Ohio Furnace, in Green Township.

Tionesta Coal Horizon.—In Jackson County the shales, and especially the calcareous sandstones above this coal, are exceedingly fossiliferous, but in Scioto County the horizon is not so productive, although many good specimens may be obtained. A few localities in this county are on the hill south of the Morgan & Horton incline in Section 5, Bloom Township; at the mine on the W. L. Cook property, east of Bloom Junction, and at the mines just south of Bloom Furnace.

Vanport or Ferriferous Limestone.—This limestone, wherever found in Scioto County, is fossil bearing. A good collection may be obtained from the flint and limestone outcropping at the summit of the ridge in Section 1, Bloom Township; from the limestone at the mines of Morgan & Horton, in Section 5, of the same township; or from the flint and lime on the ridges east of Bloom Furnace.

CHAPTER V

WESTERN HALF OF GALLIA COUNTY

Importance of the Area

Gallia County came into prominence for its iron ores when Gallia Furnace, now marked only by cinder dumps, was erected in 1847. The thick deposits of coal in the Symmes and Little Raccoon valleys, and those farther east in the county, early attracted the attention of miners and operators. The thin limestones, occurring at various horizons in the geological column, have been of only minor importance in the industrial development of the county, but their part in the soil enrichment has been of marked value, as is attested by the fine fruit and grazing lands. The ceramic materials of the area have been but little attacked, although deposits of known worth, especially in the Allegheny formation, occur in many localities.

Location and Area

Gallia County is located on the Ohio River, which forms in the main its eastern boundary. On the south it is bounded by Lawrence County, on the west by Lawrence and Jackson counties, and on the north by Vinton and Meigs. According to the latest estimate of the Federal Government its area is 430 square miles.

Topography

RELIEF

The surface of Gallia County, like all the rest of southeastern Ohio, unaffected by direct glacial action, is rugged and maturely dissected. The present features are the resultant of erosive and weathering agencies that have cut deep into the old Appalachian Plateau, the outlines of which may be seen distinctly from high elevations. The hills are usually steep and, due to differential weathering of the shales and sandstones, have long lines of benches with abrupt bluffs, features common in coal formations. Although the hills are steep, the ridges, especially along the lines of outcrop of the Conemaugh rocks, are usually broad and moderately sloping, thus affording much good farming land. The principal valleys are entrenched about 300 or 400 feet below the summits of the dividing ridges. In general the flood plains of the larger streams, such as the Symmes, Raccoon, Indian Guyan, and Campaign creeks, are comparatively narrow, and in some localities restricted to narrow passes, while the smaller streams have only been able to build ribbon-like plains along their courses. Along the Ohio River the flood plain in Gallia County is often more than one mile wide, while at other places, due to the flexure of the stream, there is scarcely sufficient level land for road building. The old preglacial waterways left their imprints truly characterized and well outlined in Gallia County; for example, the broad expanse of elevated valleys seen at Centerville, Rio Grande, Bidwell, Rodney, and other places was formed before the advance of the ice sheet. These valleys now contain some of the most valuable farms in the county, and have been useful also in determining the location of pikes and railroads.

The elevations of a few knobs in the county rise slightly above 1,000 feet, but the main ridges average much lower than this, usually between 850 and 950 feet. The highest group of hills is found in southern Greenfield Township, although in Perry, northeast of Patriot, there are a few ridges equally as high. The general slope of the land is more directly towards the preglacial streams than towards the present streams, for the former, advanced in age, have reduced the land well towards their headwaters, thus leaving the hills adjacent to the courses especially low and well rounded. The main work of the present streams, often flowing with but little regard to the old waterways, has been to intrench their courses 60 or more feet below the main preglacial drainage lines. Some of the highest ridges in the county are close to Raccoon and Symmes creeks. The elevation of the flood plain at the mouth of Raccoon Creek, the largest through-flowing stream in the county, is about 525 feet, and where the stream enters Gallia from Vinton County it is about 605 feet. Since the fall is thus 80 feet and the length of the stream within the county approximately 41 miles, the gradient is about 2 feet per mile. On Symmes Creek the gradient is about 2.3 feet per mile. The fall along the lower courses of the smaller streams is considerably greater than this, while near their headwaters the descent is rapid.

DRAINAGE

The surface waters of Gallia County flow either directly or indirectly into the Ohio River which forms its eastern boundary. The largest through-flowing stream is Raccoon Creek, which enters the county from the north and, flowing in a general southern direction through Huntington, Raccoon, Perry, Green, Harrison, and Clay townships, empties into the Ohio River near Raccoon Island. Symmes Creek, which crosses the western part of Gallia County, flows through Greenfield, Perry, and Walnut townships. Indian Guyan Creek drains Guyan Township. From Guyan Township the main stream, flowing in a southern direction through Lawrence County and nearly parallel to the Ohio River, empties into the latter near Bradrick.

SURFACE ROCKS

Stratigraphy

The area in which the rocks were examined, and hence discussed in this report, is that of western Gallia County, comprising Huntington, Raccoon, Greenfield, Perry, and parts of Morgan, Springfield, and Walnut townships. A sedimentary origin is evident for all the rocks appearing at the surface within this field. They were deposited in water or by the agency of water and consist of sandstones, limestones, shales, coals, iron ores, and clays. The alluvium deposits laid down during inundation periods on the flood plains of the present streams are of recent origin, while the more compact clays, gravels, and sands, found in the terraces bordering the larger water courses, and in the valleys of the preglacial rivers, are of Pleistocene Age. Excepting these, which constitute only a small part of the total mass, the rocks were all deposited during Pennsylvanian time. The total thickness of the strata exposed from the Tionesta coal, seen in the stream bed in northwestern Greenfield Township near old Cambria Furnace, to the Ames limestone, found in a number of localities in central Gallia County, is about 430 feet.

QUATERNARY SYSTEM

RECENT DEPOSITS

During flood periods the streams carry loads of silt, sand, and gravel, parts of which are deposited along their beds or on their flood plains. Due to the differentiating power of running water the fine materials are left in the quiet waters on the flood plain, while the coarse parts are deposited near the main stream. These materials may be worked over many times, deposition taking place in some areas while cutting is going on in others, contributions being thus added or removed by each rain. The beds so laid down form the Recent deposits, which usually extend well towards the headwaters of even the smaller streams.

The thickness of the deposits depends on the volume of water, on the gradient of the stream, and on the character of the strata in the water basin. Along the Ohio River the beds often reach 50 feet in thickness, while along Raccoon and Symmes creeks they seldom exceed 30 feet. Along the small streams the bedrock is usually found at a depth of only a few feet. Due to the variability of the depositive forces the beds are very irregular in their composition and in the arrangement of the separate layers. Lenticular and irregular masses of sand or gravel are found interbedded with clays, or the clays with the sands. No constancy of relation is shown except in a general way. Vertically the usual order of arrangement is bowlders and coarse gravel near the bedrock, then sands and gravel with some clays interbedded, and then, lastly, clays with more or less sands erratically distributed; while longitudinally there is an imperfect gradation of materials from the headwaters of the stream, where the coarse matter not readily transported is found, to the mouth, where the clays and fine sands are carried even by a sluggish current.

These Recent deposits are of more value for their agricultural features than for their industrial uses, since on them the light loamy soils and mulch from the upland are laid down during inundation periods. The clays, however, have considerable value for ceramic uses, being well adapted for the manufacture of common brick and draintile. They may also be used to good advantage in making roofing tile, fire proofing, and fancy building brick. The working properties are usually excellent, as they may be formed with ease into the shapes desired. The ware thus formed dries safely under almost any common method of heat treatment. The vitrification range, during burning, is moderately long, especially with the clays carrying considerable siliceous matter. The best structure is developed between 1,700° and 2,000° F.; the definite temperature depending of course on both the amounts and kinds of bases present. The burned ware is rather free from deleterious defects, such as cracks, warping, or deformation.

The uncertainty of the deposits largely restricts their use, for the beds may feather out or become interstratified with sands in a short distance. Before the erection of a plant for their utilization, thorough prospecting to determine both the amount and character of the material available is advised. The clays have been used to a small extent for common ware at Gallipolis, Bidwell, and Vinton. At present, they are not worked regularly at any place within the area under discussion.

PLEISTOCENE DEPOSITS

Throughout Gallia County are found many old preglacial valleys with thick deposits upon their floors, which evidently were laid down during glacial time. Near the villages of Centerville, Rio Grande, Vinton, Bidwell, and Rodney these old waterways are very apparent and their age is well shown by surface features. The hills adjacent are low and well rounded, the valleys broad and distinctly defined, and the floors flat-bottomed but slightly graded. These valleys are in marked contrast to those of the present streams. For a more complete description of the preglacial drainage the reader is referred to the work of W. G. Tight.[1]

In many respects the deposits found here resemble those laid down by the present streams, but as a general rule they contain much less coarse material. In the main, they are clays and fine-grained sands, although on the valley floors a thin layer of gravel and bowlders is occasionally seen. Bowlders of flint or chert, which were derived from some limestone found in places towards the source of the stream, occur locally intermingled with the finer materials. The clays are finely stratified, denoting deposition in quiet waters. The materials composing them have been so completely comminuted that the clays have a soapy feel and a high plasticity. The color varies from light to gray, or, where weathered, from yellow to brown. In these old valleys such clays are best seen on divides of the present streams for here the original deposits have been least disturbed. These same features may also be seen in the clays of the terraces along the preglacial valleys.

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[1] U. S. Geol. Survey, Prof. Paper 13, 1903.

The surface clays, where considerably weathered, make a good grade of the common classes of ceramic products. On account of their abnormally high shrinkage and their short vitrification range, the soapy, finely stratified clays are excluded from the ceramic field although the color of the burned body is pleasing. In local areas, some of the lower layers contain sufficient siliceous material to produce normal burning behavior. On the whole these clays should be thoroughly tested before any considerable outlays for ceramic plants are made. Like the clays, the sands found in these deposits are with few exceptions fine-grained. They are stained to a certain extent with iron oxides and contain small amounts of argillaceous matter. In a few localities sand for local needs is taken from these beds, but at no point have they been worked in a large way. The physical qualities of the sand suggest its fitness for use as molding sand.

PENNSYLVANIAN SYSTEM

The great mass of rocks forming the hills and valley floors of Gallia County belong to the Pennsylvanian system. This is the great coal-bearing division of rocks in the United States.

Structural Features

In Gallia County the general dip of the rock is towards the Ohio River. It varies locally and is somewhat greater in the northern part of the county than in the southern part. The average dip east, measured by the Ferriferous limestone, Middle Kittanning coal, and Cambridge limestone, is about 31 feet per mile. The dip of the rocks south is more constant. Measured by the Upper Freeport coal and the Cambridge limestone, it is slightly less than 10 feet per mile. From these results the strike of the rocks is calculated to be 17° 53′ east of north. The maximum dip is of course at right angles to this or 17° 53′ south of east. It amounts to 36 feet per mile.

In the southern part of Greenfield Township there is a marked arresting of the dip, and the general trend of this area is north and south. It may be traced south some distance into Lawrence County where it crosses Johns Creek near Sherritts, thence across Aaron Creek and finally across Elkins Creek near Oak Ridge Furnace. . These features traced northward fade out before reaching the Jackson-Gallia line. This arresting of the dip in a minor degree is also apparent along Raccoon Creek from Vinton to Cora.

Minor features of interest are the variations of the intervals separating members such as coals, limestones, or iron ores. Massive sandstones play a prominent part here. They appear to act as wedges crowding some members closer together and pushing others farther apart. The normal interval from the Lower Kittanning coal to the

Ferriferous limestone is about 25 feet, but north of Gallia Furnace where a massive sandstone is found above the coal, the remnant of this bed is only 16 feet from the limestone. Due also to this sandstone the Lower Kittanning and Middle Kittanning coals are separated by an interval of about 75 feet, while the normal distance is about 40 feet. Along Little Raccoon Creek, in Section 19, Huntington Township, the two members are only 27 feet apart. Where shales predominate the interval from the Cambridge limestone to the Upper Freeport coal below is usually about 130 feet, while in Section 13, Greenfield Township, where heavy sandstones appear, this expands to 177 feet. These abnormalities are rather to be expected since the sandstones represent shore or delta deposits.

Relations of Coals and Other Important Beds in Western Gallia County

System.	Series.	Formation.	Member.
Pensylvanian		Conemaugh	Ames limestone.
			Cambridge limestone.
			Wilgus coal.
			Brush Creek member.
			Mason coal.
			Mahoning coal.
			Mahoning sandstone.
		Allegheny	Upper Freeport, Waterloo, or No. 7 coal.
			Upper Freeport, or Bolivar clay.
			Lower Freeport, or No. 6a coal.
			Middle Kittanning, Sheridan, Hocking, or No. 6 coal.
			Middle Kittanning clay.
			Lower Kittanning, Newcastle, or No. 5 coal.
			Lower Kittanning clay.
			Ferriferous ore.
			Ferriferous, Hanging Rock, or Vanport limestone.
			Clarion, Limestone, or No. 4a coal.
			Clarion clay.
			Clarion, or Hecla sandstone.
			Brookville, or No. 4 coal.
		Pottsville	Black Flint member.
			Tionesta, or No. 3b coal.

A general section of the surface rocks of western Gallia County is given to show the order of the succession of the various members, and the average thickness of the beds when well developed.

	Ft.	In.
Limestone, *Ames*	1	--
Shales and sandstones, with thin coals	78	--
Limestone, Cambridge	2	--

		Ft.	In.
Coal, *Wilgus*		1	--
Shales and sandstones		26	--
Limestone	*Brush Creek*	2	--
Shales		24	--
Limestone		2	--
Shales		10	--
Coal, *Mason*		1	--
Shales and sandstones		28	--
Coal, *Mahoning*		1	--
Clay shales		2	--
Shales		10	--
Sandstone, *Mahoning*		30	--
Coal	*Upper Freeport*	1	3
Clay shales		--	5
Coal		--	7
Clay		--	3
Coal		3	1
Clay, *Upper Freeport*		3	--
Sandstones and shales		50	--
Coal, *Lower Freeport*		1	4
Sandstones and shales		24	--
Coal	*Middle Kittanning*	1	--
Clay shales		--	5
Coal		2	1
Clay, *Middle Kittanning*		3	--
Sandstones and shales		35	--
Coal, *Lower Kittanning*		1	8
Clay, *Lower Kittanning*		7	--
Clay, sandstones, and shales		16	--
Ore, *Ferriferous*		--	4
Limestone, *Ferriferous*		6	--
Coal	*Clarion*	1	2
Clay shales		--	7
Coal		1	3
Clay, impure		--	1
Coal		--	11
Clay, *Clarion*		2	--
Sandstones, *Clarion*		31	--
Coal, *Brookville*, wanting.			
Flint and ore, *Black Flint* horizon		1	--
Shales, with ore layers or sandstones		9	--
Shales, fossiliferous		12	--
Coal, *Tionesta*		1	4

POTTSVILLE FORMATION

In Gallia County in the northwestern part of Greenfield Township about 40 feet of rocks belonging to the upper part of the Pottsville formation, the basal division of the Pennsylvanian system, appears above drainage. This formation begins with the Sharon conglomerate and ends with the Tionesta or Homewood sandstone. In Jackson County to the west, it is exposed in its full thickness and carries coal beds of exceptional economic importance. At present in the county under discussion but little is known regarding these lower coals, for they are under deep cover and hence the only source of information is from drill records most of which were made when testing the rocks below for oil. The meager evidence thus obtained fails to give a definite clue to the situation but points more toward the absence than the presence of workable deposits. Future work in the area may change this opinion. The Pottsville formation is divided into a number of members, but only those appearing at the surface will be described here. These are the Tionesta coal and the shales and ore on the Black Flint horizon.

TIONESTA OR No. 3b COAL

The Tionesta coal is found about 28 feet above the Upper Mercer ore or limestone, when either of these is present, or about 35 feet below the Brookville coal, the basal member of the Allegheny formation. Since the latter coal is seldom present in southern Ohio, a better bench for reference is that of the Ferriferous or Vanport limestone, from which the Tionesta coal in this locality is separated by an interval of approximately 60 feet. The bed along its outcrop in Jackson and Scioto counties is very unsteady, for in many localities it is completely replaced by massive sandstones. Its variability in structure is also marked for the stratum may be represented by bone shales, by bone shales interstratified with thin coal bands, by a series of coal benches separated by clay partings, or by a thick deposit of clean coal. Reasoning from its surface behavior, but little should be expected of the stratum under cover in Gallia County, although small areas of good coal may be located.

The coal bed was not seen, but near old Cambria Furnace, Section 7, Greenfield Township, it is reported to lie in the stream bed, from which it was mined by stripping. This is the only place in the county where the horizon of the coal is above drainage. The fossiliferous shales, which mark the horizon immediately above the coal in other localities, are exposed along the banks of this stream, so the position of the coal at most is only a few feet below. The section taken here is given below in order to show the relation of the Tionesta coal to higher members in the scale:

	Ft.	In.
Limestone, *Ferriferous*	5	--
Coal blossom, *Clarion*	2	--
Clay and covered	3	--
Sandstone, shaly and thin-bedded	11	--
Sandstone, massive	27	--
Shales	4	8
Ore, nodular, *Black Flint* horizon	--	4
Sandstone, shaly	5	6
Sandstone, shaly, very fossiliferous	2	6
Shales, sandy	1	--
Shales, dark, calcareous	2	6
Coal horizon, *Tionesta.*		

The Tionesta coal belongs to the free-burning class, resembling in this respect the two Mercer coals below. Along the borders of the coal basins a part or the whole of the stratum may be cannel coal of fair quality. The ash in the fuel is moderate in amount and non-clinkering under ordinary conditions of firing, while the sulphur content compares favorably with that of the average market coal. This component, occurring in the form of pyrite, is distributed mainly in thin bands along the bedding planes. The coal makes a good heat, and on the whole is well suited for domestic and steaming purposes.

Shales and Block Ore Near the Black Flint Horizon

In the interval from the Tionesta to the Brookville coal, the latter here replaced by massive sandstones, the shales and shaly sandstones are somewhat calcareous, and along certain zones very fossiliferous. Thin deposits of carbonate ores are also common. While the range in thickness is from 15 to 30 feet the average thickness is about 25 feet. The general character of the deposits indicates that during their deposition the tendency was somewhat toward limestone formation. The fossiliferous sandstone, found only a few feet above the Tionesta coal near Cambria Furnace, contains nearly 30 per cent of calcium and magnesium carbonates, and in appearance resembles impure limestone. In the northern part of Jackson County black flint with ore and calcareous shales is found just below the horizon of the Brookville coal, while to the east of the town of Jackson the flint is wanting, but its position is marked by the presence of one or more block ore layers. The ore found just above drainage on Lefthand Fork, Section 7, Greenfield Township, evidently belongs either on or just below the flint horizon. While the old furnace was in blast this ore was mined to a small extent by stripping. It is quite siliceous and low in iron, hence it has but little value at present.

ALLEGHENY FORMATION

The Allegheny formation in Gallia County is of noteworthy importance, for it contains five coal beds, from which may be drawn a large supply of fuel. It contains also clays, shales, iron ores, and limestone of value. This formation begins with the Brookville coal, which is wanting in this area, and ends with the Upper Freeport coal, which for years has been the main reliance for fuel in the Waterloo region. The total thickness of the formation is about 180 feet. Its base is found above drainage only in northwestern Greenfield Township. Dipping eastward it disappears from view in the Raccoon Valley from the Vinton County line to the central part of Perry Township, thence in the Symmes Valley to the Lawrence County line. The Allegheny formation is sub-divided into a number of members, which will be taken up in regular order beginning with the oldest.

BROOKVILLE OR No. 4a COAL

The Brookville coal marks the base of the Allegheny formation. The normal position of the bed is from 20 to 30 feet below the Clarion coal, or 25 to 35 feet below the Ferriferous limestone. This coal should occur in northwestern Greenfield Township, but it is replaced by the massive Clarion or Hecla sandstone. Since the Brookville coal is usually wanting in southern Ohio, or when present, thin or bony, excepting in one locality, the prospect for productive fields under cover is very discouraging.

CLARION OR HECLA SANDSTONE

The next member in the ascending scale is the Clarion or Hecla sandstone, which is quite persistent in southern Ohio. It usually occupies the entire interval between the Clarion and the Brookville coal, but in some places it cuts far down into the Pottsville formation or coalesces with the Homewood sandstone, so that the two members appear as a single bed. In Gallia County the Clarion sandstone is present in the localities where it is due. Its area above drainage is small, since it is found only along the streams in the northern part of Greenfield Township and along Little Raccoon Creek, in Section 18, Huntington Township.

An item of interest in regard to the Clarion or Hecla sandstone is that in the days of the charcoal iron industry in southern Ohio it was widely used for hearthstone. It has good heat-resisting qualities and its chemical composition is such that it is well suited to counteract the action of acid slags. The stone is composed of quartz sand with a small amount of clay and basic materials for the bonding matter. The total fluxes are low.

CLARION CLAY

The Clarion clay, the position of which is directly below the Clarion or No. 4a coal, is not an important mineral asset of Gallia County. The bed, where observed, averages about 3 feet in thickness. The clay is usually very siliceous and gradates into the Clarion sandstone below. Locally, small lenses of flint clay are found in the upper part of the bed, but this clay is seldom pure. Since the value of the Clarion clay is far overshadowed by the Lower Kittanning clay above, its use for industrial purposes is practically eliminated.

CLARION, LIMESTONE, OR No. 4a COAL

The Clarion, or No. 4a coal is the second coal stratum in the Allegheny formation. Due to its proximity to the Ferriferous limestone, it is often designated Limestone coal. Where both members are present, the coal and limestone are in direct contact, or at most, separated only by a thin layer of shale. The Clarion coal is not a persistent deposit for, even where the limestone is present, the upper bench of coal or the entire bed may be wanting. Again, the massive sandstone, found locally on the horizon of the Lower Kittanning clay, may replace both limestone and coal. These conditions are all illustrated in Gallia County.

The Clarion coal, when normally developed, is made up of three coal benches with two clay partings. The average thickness of the separate layers is about as follows: lower bench, 11 inches; middle bench, 1 foot 3 inches; upper bench, 1 foot 2 inches. The lower parting composed of clay with pyrite nodules is only about 1 inch in thickness, while the upper bench, made up of clay with thin coal and bone shale bands, is about 7 inches. Bone partings are not common in the coal itself. A few sections will be given in order to illustrate the various structural phases of the Clarion coal in Gallia County.

Near the head of Kokeene Hollow, Section 18, Greenfield Township, the Clarion coal has been mined by stripping on the land of Wesley Clarkson. The bed was not exposed for measurement, but Mr. Clarkson reports the rocks here as follows:

		Ft.	In.
Limestone, *Ferriferous*		7	--
Coal	*Clarion*	1	4
Clay		--	6
Coal		1	--
Clay with pyrite		--	1
Coal		1	--
Clay		--	6
Coal		--	6

East of the above exposure, but in the same valley, the structure of the stratum is considerably different. The upper bench of coal is here wanting, and, in local areas, the bed is represented only by a soot streak. The section given below was taken in a mine on land belonging to William Lewis, Section 8:

		Ft.	In.
Limestone, *Ferriferous*		6	--
Clay shale		--	9
Coal	*Clarion*	1	7
Clay with pyrite		--	1
Coal		--	9

The bed was also exposed on the land of John Jenkins, but the structure noted practically duplicates the above. The Clarion coal, on Lefthand Fork, in Section 7, is also unsteady, varying from normal development to a black stain. Further, this is the condition reported in Pokepatch Hollow, where the bed is found close to drainage level. A section taken in the limestone mine of N. A. Wood, at Gallia, shows the condition of the coal in this locality. The measurements follow:

	Ft.	In.
Ore, *Ferriferous*	--	3
Limestone, *Ferriferous*	4	6
Coal, rotten, *Clarion*	1	--

Along Black Fork Creek, in sections 9 and 10, the stratum, where seen, is represented by only two coal benches or by a foot or so of decayed coal. In Section 18, Huntington Township, the horizon again appears above drainage. Here, in local areas, a massive sandstone has replaced both limestone and coal, but the latter, when present, has normal structure. Along Raccoon Creek the bed disappears below cover about 1 mile north of the Gallia County line; hence it should be only slightly covered in northern Huntington Township.

Extent and Economic Features

The area above drainage in Gallia County underlain by Clarion coal is small, not exceeding 10 square miles. Along Lefthand Fork, in Section 7, Greenfield Township, the coal is from 60 to 80 feet above the stream, while in Kokeene Hollow, in sections 8 and 16, the interval is only about one-half this. Along Pokepatch Hollow, the horizon is just above drainage in the western part of Section 20 and in the eastern part of Section 19, but in the latter it again appears in the southwest corner. The Ferriferous limestone is found along the flood plains of Dirtyface Creek in the northwestern part of Section 29, so the coal if present may be obtained by stripping. At Gallia, the remnant of the bed is found near water level. Along Black Fork Creek, in Section 9, it occurs near the base of the hill and in Section 10 disappears near where this stream joins Symmes Creek. The Clarion coal appears above drainage in only one locality in Huntington Township, which is along Little Raccoon Creek in Section 18, and near the mouth of a small tributary in the western part of Section 7. The bed is within easy shafting distance in other parts of northern Huntington Township, for the strata, appearing at the surface on Spring Run and Raccoon Creek, show that the coal horizon is not far below. At Miller's ford in Section 12, west, Walnut Township, the Lower Kittanning coal is about 15 feet above the level of the waters of Symmes Creek, so the Clarion coal should be found at a depth not to exceed 20 feet. For a few miles along this stream the cost of shafting the coal would not be excessive.

Extent and Character Under Cover

In Gallia County the extent and character of the Clarion coal under cover are not known, as but little accurate testing by the drill has been done. Owing to the unsteadiness of the bed in southern Ohio it is scarcely safe to predict in regard to these features, but from surface conditions probable conclusions may be drawn. In Lawrence County, the southern boundary of the productive field is marked by a line drawn from east to west through Moulton. In that part of Decatur Township north of this, the bed is quite persistent and well developed. Near the Rehmer School on Buffalo Creek, Symmes Township, the coal, where exposed in the bed of the stream for a short distance only, is thin and rotten. In Greenfield Township, Gallia County, the eastern exposure of the deposit on Dirtyface Creek, in Pokepatch and Kokeene hollows, and on Black Fork Creek, shows but little coal of value, and in fact this line appears to mark the boundary of the field. The coal is somewhat patchy where it disappears below drainage farther east in Madison and Bloomfield townships, Jackson County. North of this on Greasy and Buffalo runs in Milton Township of the same county, the bed is quite steady and has normal structure. This is the condition also found near Minerton and Clarion in Wilkesville Township, Vinton County. These surface indications suggest, therefore, that the most likely field under cover should be found in northwestern Huntington Township. Near the line drawn from the Gravel Hollow School, Section 18, Huntington Township, Gallia County, to the Rehmer School, Section 8, Symmes Township, Lawrence County, the coal is patchy, thin, or completely wanting. These adverse conditions will evidently carry under cover for some distance at least, and this line may mark the eastern productive limit of the field. At best the prospects east of this are somewhat discouraging and the presence of the coal should not be assumed, although this zone may be only a local disarrangement in a large field, the limits of which are yet undefined.

Quantity

A close approximation to the quantity of Clarion coal above or near drainage in Gallia County is difficult to make owing to the unsteadiness of the bed. In the main ridge in western Greenfield Township in which the bed is known to be probably constant there is an area of about 5 square miles. To this must be added the field along Little Raccoon Creek in northwestern Huntington Township, embracing at least 2 square miles. From present knowledge no trustworthy estimate of the area of good coal under cover should be attempted, but the conditions at least favor a productive area in northern Huntington Township.

Economic Features

The Clarion coal yields but little fuel at present in Gallia County. Small amounts are mined for local domestic use on Lefthand Fork and in Kokeene Hollow, Greenfield Township. Along Little Raccoon Creek it has not been attacked since other beds supply the necessary wants.

The Clarion coal belongs to the high volatile, free-burning class, but is quite distinct in its behavior for it burns freely only while the gaseous matter is being consumed. The fixed carbon burns slowly. It is an oily coal and has a high cementing value, making coke of good structure under ordinary conditions. The ash of the coal as ordinarily mined usually runs from 12 to 15 per cent, but a part of this is derived from the partings and must be attributed to dirty mining. In the clean coal this component varies from 8 to 12 per cent. The main deleterious factor in the coal is the sulphur, the amount of which averages more than 4 per cent. This element occurs both in the form of iron disulphide and in that of organic compounds, where the sulphur is combined directly with the vegetable matter. The thin parting between the lower and middle benches of coal is made up of clay and pyrite, and the amount of the pyrite is often in excess of that of the clay. This layer and the sulphur nodules found in the coal itself should be carefully excluded. When the coal is mined cleanly the clinkering of the ash is not especially troublesome, but otherwise it often prohibits the use of the coal. The heating value of the Clarion coal compares favorably with that of other southern Ohio coals. When clean coal is supplied it is well liked for steaming purposes. The sulphur content and the sooty character of the fuel are detrimental to it for domestic use. Although the Clarion coal grades low among Ohio coals, the deposit is well worthy of recognition in computing the mineral wealth of Gallia County.

FERRIFEROUS LIMESTONE

The Ferriferous limestone is the important bench mark in the Allegheny formation of southern Ohio from which geological sections are so repeatedly measured, or, in other words, it is the guide post which frequently rights the lost stratigrapher. Its position is directly above the Clarion coal, and from 25 to 35 feet above the Brookville coal, the basal member of the Allegheny formation. It is the only true, regularly bedded limestone in this division of rocks; however nodular, fresh-water limestones occur at higher horizons. The bed was laid down in a compact mass with only slight stratification lines along which it tends to open on weathering. The stratum is variable in composition. In some localities from 1 to 4 feet of flint or chert are found in the upper part of the bed, while at other places irregular masses of flint are distributed through its entire thickness. These features are all found in Gallia County; hence a few sections are given for their illustration.

The Ferriferous limestone was exposed for measurement at a few places along Lefthand Fork, Section 7, Greenfield Township, and a record obtained near old Cambria Furnace is as follows:

	Ft.	in.
Ore, *Ferriferous*	--	4
Limestone, *Ferriferous*	5	--
Coal, rotten, *Clarion*	2	--

The thickness of the deposit in Kokeene Hollow is variable, but the usual measurement is from 5 to 7 feet.

At other places along Clear Fork north of this, the flinty part of the bed, noted in the above section, is much thicker, and in local areas flint appears in the entire deposit. The Ferriferous limestone was not favorably exposed for measurement in Pokepatch Hollow, but it is reported to average about 6 feet in thickness. On Dirtyface Creek, in Section 29, flinty limestone was seen at drainage level, but the thickness of the bed was not obtained. The measurement of this stratum, taken in the mine of N. A. Wood, at Gallia, and given below, shows the usual thickness of the deposit in this locality:

	Ft.	In.
Ore, *Ferriferous*	--	3
Limestone, *Ferriferous*	4	6
Coal, rotten, *Clarion*	1	--

In this mine the thickness of the bed is somewhat variable, ranging from 3 feet 6 inches to 6 feet, but the quality is up to standard, for the stone is quite free from flint or cherty material. In the cut of the Cincinnati, Hamilton & Dayton Railway north of Gallia, the bed is again well exposed, and measures 5 feet in thickness.

In Huntington Township the Ferriferous limestone is above drainage in only one locality, which is along Little Raccoon Creek and its small laterals in sections 18 and 7. Here in restricted areas, the bed is replaced by sandstone, but where present, the thickness averages from 5 to 7 feet. The quality of the stone also is generally good.

But little is known at present in regard to the extent of the Ferriferous limestone under cover.

Economic Features

The Ferriferous limestone was of great importance during the days of the charcoal furnaces, for it furnished the necessary flux stone required in iron smelting. From this bed old Gallia Furnace, the only stack built in Gallia County, drew its main supply of limestone for many years. Since the stone averages about 94 per cent calcium and magnesium carbonates, it is well suited for metallurgical purposes, and is used to some extent by the modern furnaces in Jackson and Lawrence counties. The sulphur is low and the phosphorus within the limits required for making iron of any grade except Bessemer.

The suitability of the Ferriferous limestone for highway construction is well shown by the many miles of excellent macadamized roads found along its line of outcrop. While it has not been so largely used for road work in Gallia County, it is the main reliance in Jackson, Scioto, and Lawrence counties. The general wearing qualities of this limestone are on a par with those of others used in the State. The stone is hard, yet has great toughness. Its impact strength is high but the cementing value of the dust is low. The crushed stone is also highly recommended for concrete, as it holds the cement well, and as the interlocking of the angular fragments gives great crushing strength. It has been widely used in Gallia and the adjoining counties to the west in bridge, culvert, and foundation work, and to a less degree in house, barn, and silo construction.

In southern Ohio, the soils derived largely from the decay and weathering of the Pottsville and Allegheny rocks have, on the whole a low content of lime. As this component is one of the few substances required for the growth of plant life, and, as it is especially necessary to legumes, the nitrogen producing order, the limestones of the county at once become a subject of interest on account of their agricultural value. Western Gallia County is within the belt of low lime soils, which fact is well shown by observing the large number of acid non-calcareous loving plants found, and by noting the impoverished state of those requiring a soil rich in lime. The fine blue grass sods found along the outcrop of the Conemaugh formation, in central and eastern Gallia County, should be attributed to the lime disseminated throughout the shales, and the ease of germination of the legumes and their hardiness are in marked contrast to that in the western part of the county.

The Ferriferous limestone is well suited for agricultural purposes. The content of calcium carbonate is about 93 per cent, while that of magnesium carbonate is approximately 1 per cent; hence the ratio of these components is well balanced for the requirement of plant life. The stone also contains phosphorus, which is slowly available for nourishment. The amount of this is small, yet computed to phosphorus pentoxide, the state in which it occurs in the stone, and in which it is taken up by the plant, it equals .2 per cent. This means 4 pounds of phosphoric acid per ton of limestone. There is always present in the fresh limestone a small amount of iron disulphide, which at first may have a slight toxic effect on the plants, but as this compound soon weathers to the sulphate, which, according to some authorities, is beneficial, its action may be neglected. The silica, alumina, and iron oxides, making up about 5 per cent of the stone, may be regarded neutral substances.

N. A. Wood is the only person or firm preparing the Ferriferous limestone for agricultural purposes in Gallia County. His plant is located at the village of Gallia, and the site is well chosen, for the limestone, outcropping near by, has a massive sandstone above, which forms the roof of the mine. Under such conditions, mining is both economical and safe. The Cincinnati, Hamilton & Dayton Railway affords shipping facilities to distant points. The local trade is good for the farmers in this locality are fast appreciating the benefits derived from the proper application of lime. The stone, mined in the regular way, by drilling and then shooting off the solid, is hauled on tram cars with mule power. The coarse grinding is done in a jaw crusher which breaks the blocks of stone to pieces about 1 inch in diameter. A Jeffrey pulverizer is used next, and it reduces the material to a fine powder, very suitable for agricultural purposes. The necessary power is obtained from a steam engine using coal as the fuel.

The grinding capacity of the plant is 25 tons per day. The pulverized limestone is marketed on a guarantee of 90 per cent calcium and magnesium carbonates.

FERRIFEROUS ORE

The Ferriferous ore was the most important bed of rock in southern Ohio during the palmy days of the charcoal furnaces, for it was along the outcrop of this ore that the industry flourished best. It was the main reliance of the furnaces, and, when these ran, times were good, for work was plentiful and brought a fair reward, and trade was active, for the farmer and merchant found a ready market for their products. The iron produced commanded the highest market prices, for its excellence was known far and wide; hence fair returns on the money invested were realized by the stockholders. To the Ferriferous ore, then, much of the early activity and wealth of the area must be credited. Since this time, the importance of the Ferriferous ore has diminished, until at present it can be considered an asset of only small importance, for these furnaces, with one exception, are known only by abandoned stacks or by heaps of cinders.

The Ferriferous ore lies directly above the Ferriferous or Vanport limestone. Usually the ore and limestone are separated by a thin parting, but in some localities the two beds have so coalesced that no line of demarcation is recognized. The thickness of the deposit is variable. Where observed in Gallia County the measurements show from 1 inch to 1 foot, but in restricted areas it is reported to have a thickness of 2 feet. On the outcrop the ore has a decidedly concretionary or blocky structure, but under heavy cover this is not so apparent. The iron was laid down as ferrous carbonate with a small amount of admixed argillaceous and calcareous ingredients. Along the outcrop or under shallow cover the ferrous carbonate has weathered to the hydrated ferric oxides. It is then classed as a limonite ore.

The Ferriferous ore is found along Lefthand Fork, in Section 7, Greenfield Township. Here, as it was mined by stripping for use at Cambria Furnace, during its active period, the ore is not well exposed for measurement, but is reported to vary from 3 to 12 inches in thickness. The ore has good volume evidently in Kokeene Hollow, since it has been benched to deep cover. Wesley Clarkson states that, while the deposit varies in thickness from a few inches to 2 feet, the average measurement is from 6 to 10 inches. The thickness of the ore conforms in a measure to the irregularities of the upper surface of the limestone below, because, where there is a low depression in the limestone the ore is quite thick, and conversely, on the most elevated portions, it is thin. The thick deposits of ore are, with few exceptions, local. In Pokepatch Hollow the best deposits of ore are reported to have a thickness of about 1 foot. The ore is thin and flinty where it appears at the surface on Dirtyface Creek, in Section 29, Greenfield Township. In the mine of N. A. Wood, at Gallia, the Ferriferous ore is well exposed, and its thickness is probably typical of the entire locality. The thickness varies from a mere stain to 8 inches, but the average measurement is about 3 inches. North of Gallia, where exposed in the cut of the Cincinnati, Hamilton & Dayton Railway, the ore measures 5 inches. At the abandoned Black Diamond mine, in Section 9, Greenfield Township, the ore is again well exposed in the prospect mine, found near the base of the hill:

	Ft.	In.
Ore, *Ferriferous*	--	10
Limestone, *Ferriferous*	3	--

The Ferriferous ore is found above drainage in one locality only, in Huntington Township, which is along Little Raccoon Creek, in sections 7 and 18. Because the bed was mined by stripping for use at Keystone Furnace, outcrop exposures were seldom seen, but from a few observations and reports, the thickness of the ore is estimated to vary from a few inches to 1 foot. No information is at hand in regard to the thickness and character of the Ferriferous ore under heavy cover.

Economic Features

The economic value of the Ferriferous ore at present is small, for the great ore beds of the Northwest now supply at a low cost the necessary demands of the iron industry. The bed is too thin to be mined for the ore alone, but it has a fair value as a secondary product when mined with the limestone below. Under heavy cover the iron present is in the form of ferrous carbonate, hence the ore must be classed as a siderite, but along the outcrop and under shallow cover this compound has been oxidized to the hydrated ferric oxides, so the ore here belongs to the limonite class. The charcoal furnaces were able to smelt successfully the oxidized ores only, consequently mining was confined mainly to stripping, and hence the great bodies of ore in the hills are yet untouched. The quality of this native ore compares favorably with that of the siliceous grades of Lake ores now on the market. The Ferriferous ore in the natural state carries from 30 to 55 per cent iron, from .10 to .35 per cent metallic phosphorus, and from .40 to 1.25 per cent manganese. It also contains small amounts of lime and magnesia, which therefore decrease the necessary addition of flux stone and promote early fusion of the slag. Thus its composition is such that it requires no mixing with other ores to produce, on smelting, foundry iron of the best quality. The ore has a high content of hydroscopic water and of volatile matter, which when expelled by heat leave the structure open or porous, a condition very favorable for ease of reduction by furnace gases. Owing largely to its physical condition, the

Ferriferous ore was readily reduced in the short stacks of the charcoal furnaces while the Lake ores, which are more compact, were smelted with difficulty. The operators of today say the ore works well in the coke furnaces, but they complain that the amounts readily available are too small to form a regular part of the burden. The worth of the bed to future generations can not be predicted, but its value to the country during the days of the charcoal furnaces will scarcely be surpassed.

LOWER KITTANNING CLAY

Stratigraphy and Extent

The Lower Kittanning clay in a few localities occupies all of the interval from the Ferriferous ore to the Lower Kittanning coal, but in most of the area it makes up only a part of this interval. The usual order of arrangement, however, in this area is that in which the clay comes directly below the coal, and sandstones or shales occupy the remainder of the interval to the Ferriferous ore below. Where the clay occupies nearly all of the interval from the ore to the coal, it is usually broken about midway by a thin band of bony coal; in fact, the deposit is really made up of two clay beds. The sandstones found in the interval have clay for their main bonding component, and they may gradate both horizontally and vertically into siliceous clays. The clay bed itself is usually made up of two parts: a fat, plastic clay which lies next to the coal and a highly siliceous clay which is below this. The total thickness of the Lower Kittanning clay interval, in Gallia County, is about 23 feet, but in this the clay bed that lies directly below the Lower Kittanning coal has the most value. It has an average measurement of about 7 feet. The remainder of the interval is usually made up of sandstones or shales.

In the area above drainage in Gallia County, the Lower Kittanning clay shows best development in northwestern Greenfield Township. It has good volume on Lefthand Fork and at the heads of Kokeene and Pokepatch hollows, but traced eastward the deposit becomes thin and broken and in local areas it is wanting. A few sections will be given to illustrate the various phases of the deposit in this area.

On Lefthand Fork in Section 7, Greenfield Township, the Lower Kittanning clay has normal thickness and quality. These features are shown by the following section taken near Cambria Furnace:

		Ft.	In.
Coal	*Lower Kittanning*	1	2
Clay		1	6
Coal		--	6
Clay, plastic, good	*Lower Kittanning*	3	6
Clay, siliceous, good		3	--

The bed has much the same character at the head of Kokeene Hollow, but it thins and becomes more siliceous towards the mouth of the valley. In Pokepatch Hollow, the Lower Kittanning clay is above drainage in sections 19 and 20, and it has excellent volume, but the coal above is thin. The clay is also divided by a parting of coal. These features are shown in the following section taken on the land of the Cambria Clay Products Company in the northeastern part of Section 19:

		Ft.	In.
Coal, *Lower Kittanning*		1	6
Clay, siliceous	*Lower Kittanning*	1	--
Clay shale		4	--
Coal		--	7
Clay, plastic, good		10	--

This clay is above drainage on the tributary of Dirtyface Creek in Section 30. Near the central part of this section, the rocks were well exposed along the roadside where the measurements given below were obtained:

	Ft.	In.
Coal, *Lower Kittanning*	1	4
Clay, part siliceous, *Lower Kittanning*	8	--

East of the above, on the farm of Cecelia Pickens, in Section 29, the clay is exposed near drainage level in a prospect mine located east of the Cincinnati, Hamilton & Dayton Railway. The section is given below:

	Ft.	In.
Coal, *Lower Kittanning*	--	3
Shale, dark	--	2
Clay, light, plastic, *Lower Kittanning*	3	--

At the village of Gallia the member is due above drainage, but both clay and coal are completely replaced by a massive sandstone. However, north of this in the railroad cut in the eastern part of Section 29, a thin deposit of clay, the measurement of which is given in the following section, was exposed near the track level:

		Ft.	In.
Coal, irregular, *Lower Kittanning*		--	8
Clay, dark	*Lower Kittanning*	1	6
Clay, light, siliceous		5	--

The Lower Kittanning clay, even when present, is poorly represented along Black Fork Creek in sections 9 and 10, Greenfield Township. Here the Lower Kittanning interval was much disturbed during or just prior to the deposition of the massive sandstone on the horizon above. The following section, taken near drainage level at the abandoned Black Diamond mine, in Section 9, illustrates these features:

	Ft.	In.
Sandstone, massive	38	--
Sandstone with finger coal, *Lower Kittanning*	1	--
Clay and shale, *Lower Kittanning*	4	--
Ore, *Ferriferous*	--	10
Limestone, *Ferriferous*	3	--

Here the Lower Kittanning coal is represented only by finger coal in the lower part of the massive sandstone, while the clay below, varying from 3 to 6 feet in thickness, is shaly and siliceous.

Huntington Township.—In Huntington Township the Lower Kittanning clay is above drainage along Little Raccoon Creek and its small tributaries from the Jackson-Gallia County line to where it disappears below cover in the northern part of Section 20. The bed is irregular in structure and somewhat uncertain in extent, since it is replaced locally by sandstones. Some of the rocks exposed along the road from the bridge across Little Raccoon Creek to the summit of the hill in the northwestern part of Section 19 are given in the following section, which illustrates the deviation of the bed from its normal structure:

		Ft.	In.
Sandstone, massive		26	6
Coal, *Lower Kittanning*		2	4
Clay	*Lower Kittanning*	4	8
Coal		--	6
Clay shale		2	--
Clay, dark		1	6
Coal		--	6
Clay, dark		4	--

The thin coals interstratified with the clay in this area are very local in extent, but layers, similarly placed, are found in the deposit in Lawrence and Jackson counties.

Walnut Township.—The Lower Kittanning clay appears above the waters of Symmes Creek in the western part of Section 12, west, Walnut Township. The following rocks were exposed for measurement at Miller's Ford:

	Ft.	In.
Sandstone, shaly	5	--
Covered	3	--
Coal blossom, *Lower Kittanning*	2	--
Clay, *Lower Kittanning*	2	--

Extent Under Cover

No definite information was obtained in regard to the thickness and character of the Lower Kittanning clay under cover in Gallia County. Above drainage there is a general decrease eastward in both thickness and quality; hence the prospects for large development under cover are not encouraging.

Economic Value

The sections of the Gallia County rocks given show that while the arrangement and character of the beds lying between the Ferriferous ore and the Lower Kittanning coal are variable, the interval contains clays suitable for ceramic purposes. The clay averages about 7 feet in thickness, and for some grades of ware the clay-bond sandstones associated with it may also be utilized. Both the clay and sandstone are buff burning and moderately refractory. The alumina in the clay varies from 25 to 37 per cent, and the bases seldom exceed 6 per cent. The working qualities of the Lower Kittanning clay are excellent; in fact, it is regarded as the standard plastic clay of Ohio. It is easily ground or crushed to the fineness desired, and it forms plastic muds by simply working or pugging with water. The mud is easily shaped into ware by molding or turning, and it flows through dies to form columns which seldom show serious defects. The green ware may be dried quickly and safely by any of the modern drying systems, but of course the kind of ware manufactured determines to a degree the type of drier to be used. The burning behavior of the Lower Kittanning clay is its best feature, and the one that gives it superiority over most of the other coal formation clays. At moderate temperatures it solidifies to a well cemented body, the density of which may be varied easily by changing the physical structure of the mass or by burning to different temperatures. The vitrification range is long, thus assuring a high percentage of properly burned ware from each kiln. The fire and also the drying shrinkages are moderately low; hence but little ware is lost through cracking, warping, or deformation. Another quality of prime importance is that the color of the burned body is stable and exceptionally pleasing, so the ware appeals to the prospective purchaser. The clay is well adapted for the manufacture of stoneware, sewer pipe, fireproofing, high-grade face brick, second-grade fire brick, and paving blocks. It is also used in the manufacture of terra cotta, roofing tile, yellow ware, and enameled tile.

The Lower Kittanning clay is directly associated with the Lower Kittanning coal, which is also a bed of importance. Both clay and coal may be mined from the same entry, and the combined thickness of the beds gives sufficient height for ease and economy in mining. The coal may be used in the manufacture and burning of the clay into marketable ware. With only ordinary economy 1¼ tons of coal give the power and heat necessary for the production of 1,000 brick; hence under these conditions a 4-foot bed of clay may be converted into ware with a 2-foot 8-inch bed of coal. In Gallia County the Clarion and Middle Kittanning coals are also present near the Lower Kittanning clay field, so they may be drawn upon if necessity demands. The Lower Kittanning clay has not been utilized in Gallia County, but the conditions are favorable for the establishment of ceramic plants, especially in western Greenfield Township.

LOWER KITTANNING COAL

The Lower Kittanning coal is one of the most valuable coal deposits in southern Ohio, for it is the main reliance for fuel in Lawrence County. It is also worked extensively in Jackson County. At present it ranks fourth in importance in Gallia County. It is far more steady than the other beds, as with fair thickness and with few wants it may be readily traced from the Ohio River near Ironton in Lawrence County to Hamden in Vinton County. The associated clays of economic worth also give the Lower Kittanning coal a special value over other coals in the area since this combination of materials has led to the establishment of large industrial plants.

Stratigraphy and Extent

When the members are considered in ascending order, the Lower Kittanning coal is the third coal deposit in the Allegheny formation; but, in Gallia County, it is the second coal deposit exposed, since the Brookville coal, which should outcrop here, is wanting. Its position in this county is about 23 feet above the Ferriferous limestone and 38 feet below the Middle Kittanning coal. Here the deposit is very unsteady and averages thin, not to exceed 1 foot 8 inches. When the bed is traced from place to place along its outcrop, the observer is impressed by the various phases shown.

Greenfield Township.—Along Lefthand Fork, near old Cambria Furnace, Section 7, Greenfield Township, the structure of the bed is normal, but the upper coal bench is somewhat thin and the clay parting exceptionally heavy. The section taken follows:

		Ft.	In.
Shale		2	--
Clay, part flinty, *Oak Hill*		1	4
Coal	*Lower Kittanning*	1	2
Clay		1	6
Coal		--	6

Farther down the valley the bed is generally thin and in places wanting. Near the head of Kokeene Hollow, in Section 18, the Lower Kittanning coal was formerly mined for local use. The coal was not exposed for measurement, but the bed is reported by Wesley Clarkson to have the following structure:

		Ft.	In.
Coal	*Lower Kittanning*	2	--
Clay		--	7
Coal		--	6

From here to the mouth of the valley the deposit is poorly represented. It is usually thin, and in some localities it is replaced by the overlying massive sandstone.

But little may be said in favor of the Lower Kittanning coal in Pokepatch Hollow, because, when present, it is thin and bony. A section taken along an old ore road in this hollow, on the property of the Cambria Clay Products Company, shows the general character of the bed in Section 19, and the measurements of the rocks are given below:

	Ft.	In.
Coal, *Lower Kittanning*	1	6
Clay, siliceous	1	--

	Ft.	In.
Clay shale	4	--
Coal	--	7
Clay, plastic,	10	--

The layer of coal, 7 inches in thickness, shown in the section just given, and separated from the coal above by 5 feet of clay and clay shale, may represent the normal lower bench of the Lower Kittanning deposit, but, from its character and extent, it appears to be only a stray bed. The stratum is above drainage in the western part of Section 20, but no coal of value was found.

The condition of the Lower Kittanning coal on the tributary of Dirtyface Creek, in Section 30, Greenfield Township, is much the same as that shown in Pokepatch Hollow. Near the head of the valley, on the Murdock property, the coal was exposed in the creek bed and measured as follows:

	Ft.	In.
Sandstone, massive	35	--
Shale	--	8
Coal, *Lower Kittanning*	1	2

Near the mouth of this stream, and on Dirtyface Creek, in Section 29, the Lower Kittanning coal is only a few inches in thickness, and in a part of the area it is wanting.

At the village of Gallia the bed is also thin, or completely replaced by the overlying massive sandstone. North of this, it is exposed in the cuts of the Cincinnati, Hamilton & Dayton Railway, and its thickness is shown in the following section:

	Ft.	In.
Sandstone, massive	20	--
Coal, irregular, *Lower Kittanning*	--	8
Clay, dark	1	6
Clay, light, siliceous	5	--
Sandstone, light, clay-bond	9	--
Ore, *Ferriferous*	--	5
Limestone, *Ferriferous*	5	--

At the abandoned Black Diamond mine, in Section 9, Greenfield Township, the horizon of the Lower Kittanning coal is near the base of the hill, and the bed is represented only by finger coals in the sandstone. This is illustrated by the following section, taken in a prospect mine:

	Ft.	In.
Sandstone with finger coals, *Lower Kittanning* horizon	1	--
Clay and shale	4	--
Ore, *Ferriferous*	--	10

This condition is found also along Black Fork Creek, in Section 10, and along Symmes Creek, in Section 11.

Huntington Township.—The Lower Kittanning coal is above drainage along Little Raccoon Creek and its tributaries, in sections

7, 17, 18, and 19, Huntington Township. The following section, taken near the residence of W. F. White, in the central part of Section 7, shows the thickness of the bed at this place, and the interval to coal higher in the geological column:

	Ft.	In.
Coal blossom, *Middle Kittanning*	1	--
Clay shale	1	--
Sandstone, parts covered	17	--
Sandstone with pebbles in lower part	8	--
Coal, *Lower Kittanning*	2	6

On the farm of A. Long, in the southern part of Section 18, the coal was exposed for measurement along the bank of Little Raccoon Creek. The record taken follows:

	Ft.	In.
Sandstone, massive	16	--
Coal, *Lower Kittanning*	2	9
Clay and covered	25	--

Along the road, in the northeast corner of Section 19 the rocks were well exposed, and the record obtained is given below:

	Ft.	In.
Coal blossom, *Middle Kittanning*	4	--
Sandstone	26	6
Coal, *Lower Kittanning*	2	4
Clay	4	8
Coal	--	6
Clay shale	2	--
Clay, dark	1	6
Coal	--	6

The two thin coal layers shown below the regular bench of the Lower Kittanning deposit in the above section, are strays, and very local in extent. The massive sandstone, often conglomeratic, found directly above the Lower Kittanning coal along Little Raccoon Creek, was laid down by currents of sufficient strength to affect the coal bed previously deposited. The irregularity in the thickness of the coal bed in most of this area, and also its absence in restricted districts, may be accounted for in this way. The Lower Kittanning coal is also above drainage at the head of the hollow in the western part of Section 6.

Walnut Township.—The Lower Kittanning coal is found near drainage level along Symmes Creek, in the western part of Section 12, west, Walnut Township. Years ago it was mined to a small extent for house use, and is reported by local parties to be from 2 feet to 2 feet 6 inches in thickness. A section taken at Miller's Ford shows its relation to the Middle Kittanning coal above. The measurements follow:

	Ft.	In.
Coal and partings, *Middle Kittanning*	3	5
Shales and covered	25	--

	Ft.	In.
Shales, sandy	10	--
Sandstone, shaly	5	--
Covered	3	--
Coal blossom, *Lower Kittanning*	2	--
Clay	2	--

Extent and Character Under Cover

The Survey was unable to collect any drill records which gave information in regard to the volume and extent of the Lower Kittanning coal below drainage level, but from the character of the bed shown along the outcrop the prospects for good fields under cover are not encouraging. Since the coal is thin and bony where exposed in adjoining territory on Little Buffalo Creek, and on Caulley Fork in Symmes Township, Lawrence County, and on Dirtyface Creek in Greenfield Township, Gallia County, the prospects for much coal of value in southern Greenfield Township are poor; however, the coal exposed along Symmes Creek near McDaniel gives some hope for a covered field in western Walnut Township. The Lower Kittanning coal, where exposed along Symmes Creek and its tributaries in northeastern Greenfield Township, Gallia County, and in Madison Township, Jackson County, is usually partially or completely replaced by a massive sandstone, which will thus continue under cover for some distance at least; hence the bed is doubtfully of economic value in northwestern Perry and western Raccoon townships. In western Huntington Township, along the Little Raccoon Valley, the coal is usually thin, while along Raccoon Creek south of Minerton, Wilkesville Township, Vinton County, the bed is thin or wanting. Such conditions do not favor the presence of large areas of well-developed coal in Huntington Township. It is not safe to advance any statement as to the condition of the Lower Kittanning coal east of the belt traced, since so many factors were operative during its deposition. The aid of the drill will be required to give definite information on this matter.

Economic Features

At a few places in Gallia County, the Lower Kittanning coal has been worked occasionally for local domestic use. The thickness of the bed, excluding clay partings, is from a few inches to about 3 feet, but the average measurement is about 1 foot 8 inches. In local areas, however, the deposit has a mean thickness of 2 feet 6 inches. The bed under normal conditions is divided into two coal benches with a parting of clay. It also has clay for the floor. These clays are aids in mining, especially where the coal is low, since the cutting may be done in them. The real roof of the coal in most of the area examined is a massive sandstone under which mining is moderately safe. In some localities the coal and sandstone are separated by a thin shale, which must be removed in mining the coal, since water readily loosens this from the sandstone above. The coal is quite free from sulphur balls, bone partings, or sand pockets; hence it drills easily and requires no sorting to yield clean fuel.

The Lower Kittanning coal burns freely during its entire period of combustion. The fixed carbon averages about 48 per cent, while the calorific value is about 1,200 B. t. u. The hydroscopic water is high as the coal is rather soft, and as it contains many thin layers of "mother coal". The sulphur, usually amounting to 2.50 per cent, occurs in the form of pyrite or marcasite, which is distributed in thin sheets along the bedding planes. The ash is clay-like in character and clinkers only at high temperatures. The usual amount of this constituent in the fuel is about 8 per cent although it varies in different localities and in different parts of the bed. The amount of soot it produces during combustion is small. In fact, in this respect it ranks much above the other coals in the Allegheny formation. The Lower Kittanning coal has a cementing value; hence it will make coke, but the product is somewhat dense and brittle as the cells have small volume and thin walls. This coal is considered an excellent steaming fuel, and when all of its qualities are duly considered it deserves a high position in the scale of southern Ohio coals. It has the main qualities desired for a general domestic coal, and it is rated by its consumers close to the Quakertown coal, which has been the standard house fuel for many years. There are only a few coals in southern Ohio that are regarded with favor for use as fuel in developing attractive shades and mature finish on the surface of ceramic ware. Of the important coals, the Quakertown bed ranks first, and the Lower Kittanning second. At present the latter coal, where found in the area above drainage in Gallia County, is usually too thin to be worked alone with economy for a general market product. Thus marketed the coal will bring into the county only a small revenue. If both coal and clay are mined, and the fuel used on the ground in the manufacture and burning of the clay into ware, which is then sold, the amount of money received will far exceed that derived from the sale of the coal alone. This utilization will also give employment to a large additional force of men.

MIDDLE KITTANNING CLAY

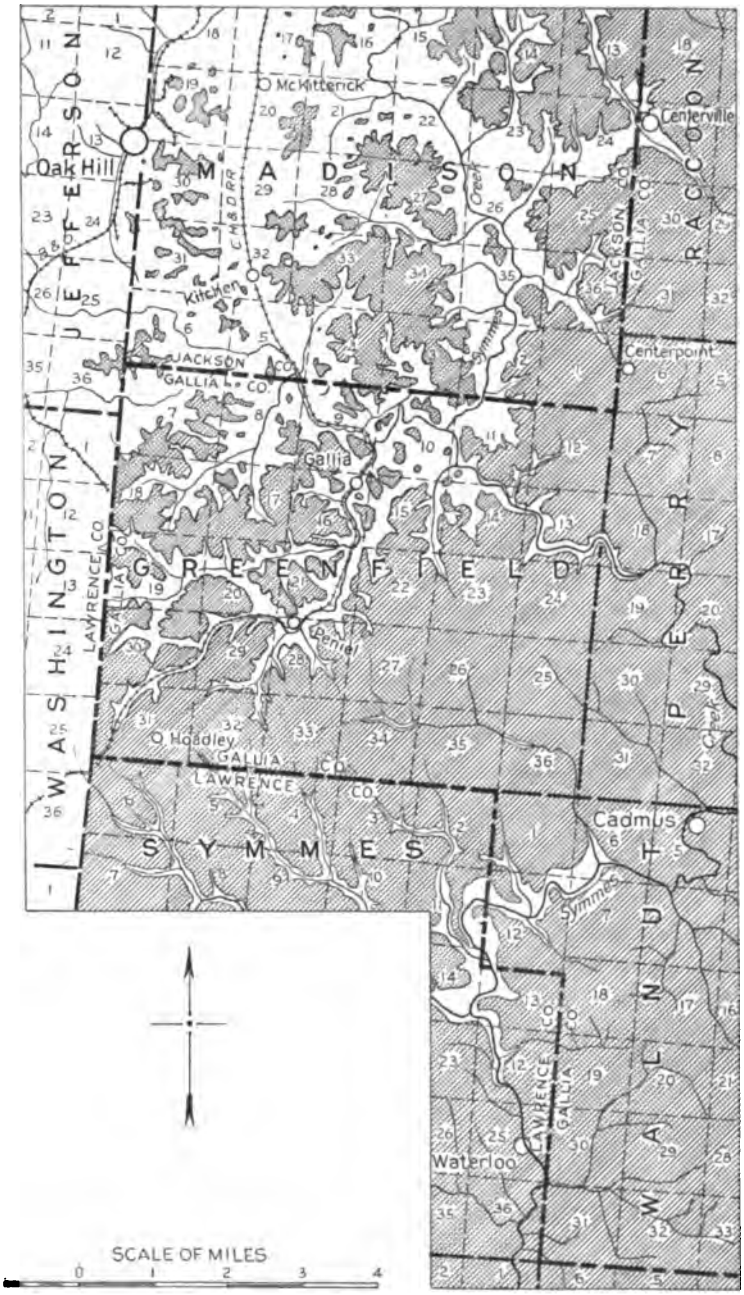
The Middle Kittanning clay lies directly below the Middle Kittanning coal, and in Gallia County it averages about 3 feet in thickness. In a few localities the bed has a thickness of 6 feet, while in other areas it is practically wanting, as the coal lies close to the massive sandstone below. The clay is everywhere siliceous, but has sufficient plasticity to be easily manufactured into ware. The deposit often contains concretionary matter which is troublesome in ceramic work. The clay and clay shales found above the Middle Kittanning coal in a number of mines are also of good quality, and they may be worked along with the clay below. These clays are more restricted in their application than the Lower Kittanning clay, but they may be used in the manufacture of a variety of products, although they are best suited for paving and building brick.

MIDDLE KITTANNING COAL

Stratigraphy and Extent

The Middle Kittanning coal lies about midway in the rocks that make up the Allegheny formation. When only the important coal beds are considered in regard to their position in the formation, it is fourth from the base and third from the top. The Middle Kittanning coal in Gallia County usually lies about 63 feet above the Ferriferous limestone, or 38 feet above the Lower Kittanning coal. From the average of the intervals measured in the county this bed is also placed about 24 feet below the Lower Freeport coal and about 78 feet below the Upper Freeport coal. However, the intervals are far from being constant, since the basins were undergoing many changes during that time. Waves were eroding land areas, or portions only slightly submerged; currents were here cutting deposits, and elsewhere laying down thick beds of sands with occasional intermingling of gravel; rivers were building up deltas of sand and silt, while during the more quiescent stages other forces were depositing limestones, shales, clays, and coals. Under such conditions of deposit constancy of interval or of structure and persistency in the extent of the beds are not to be expected. These phases are well illustrated in the rocks of Gallia County. The interval from the Middle Kittanning coal to the Lower Kittanning coal below varies in thickness from 25 to 85 feet, but from the former coal to the Ferriferous limestone it is much more constant. From the Middle Kittanning coal to the Lower Freeport coal above the interval expands from 12 to as much as 45 feet, while it averages much less in thickness here than in Lawrence County. See Map IX.

The structure of the Middle Kittanning coal in Gallia County is also erratic, but that most commonly observed is as follows,—a lower coal bench with a mean thickness of 2 feet 1 inch, a clay or clay shale parting about 5 inches in thickness, and an upper coal bench the average measurement of which is about 1 foot. In restricted areas other benches of coal, usually bony and separated by clays, are found above the main bed. The lower or principal coal bench varies in thickness from a mere mark to 2 feet 8 inches, and it may also be separated by bedding planes into two or more layers of block coals of somewhat different grades. The partings and upper coal benches are wanting in some areas, since they are often replaced by the massive sandstone found on the horizon above. The parting between the lower or principal coal bench and the one above varies in thickness from 1 inch, or even



Middle Kittanning or No. 6 Coal in Southwestern Gallia County.

less, to 2 feet. The second coal bench is wanting in many localities, but, when present, its thickness ranges from 5 inches to 2 feet. The coal benches and the partings found above the main bed in only a few localities are very unsteady in thickness and changeable in composition.

In extent, also, the Middle Kittanning coal is very inconstant, for it is subject to many wants. In some localities apparently the bed was never deposited to any considerable thickness, for the clay is found with only a marking of coal. Above the coal shale is present, indicating quiet water deposition with little erosive action. In other areas the coal bed was evidently deposited, but later eroded, since scattered remnants of the coal are found from place to place along its horizon. In parts of Greenfield and Huntington townships the interval is made up of massive sandstones, in which no trace of the coal bed is found. From this it appears that during the coal forming time conditions were favorable only for the deposition of sandstones. Many of these features are illustrated in the sections given later. The Middle Kittanning coal is above drainage in all of Greenfield, in four sections in northwestern Walnut, in two sections in western Perry, in western Raccoon, and in western and northern Huntington townships.

Greenfield Township.—The Middle Kittanning coal has fair thickness, and is quite steady in the northern part of Greenfield Township, but it thins, or in local areas goes out completely in the southern part. In sections 7 and 18 the horizon lies near the summits of the ridges, and the coal bed has a thickness of about 1 foot 8 inches. On the land of Albert Miller, in the southwestern part of section 9, the bed is mined by drifting for local use. The section taken here follows:

	Ft.	In.
Sandstone	20	--
Shale	2	1
Clay, dark	--	8
Coal, *Middle Kittanning*	1	10

In the southern part of the same section the bed is also mined near the road that leads to the village of Gallia. Besides the main coal bench there is present also another bench above, which varies in thickness from a thin stain to 1 foot 4 inches. The following measurements, illustrating the structure of the coal, were made at a mine on land of Garnett Trainer:

		Ft.	In.
Sandstone, massive		25	--
Shale		2	1
Coal, unsteady	*Middle Kittanning*	--	9
Clay shale, dark		--	4
Coal		2	--
Clay		1	--

The Middle Kittanning coal was formerly mined for railroad shipment north of Black Fork Creek, in Section 9. The bed at this place is made up of three coal benches, separated by thin partings, and has 1 foot or more of shale, and then sandstone for the roof. The influence of the various forces that deposited the massive sandstone between the two Kittanning coals is noticed in the expansion of the interval separating them from a normal distance of 38 feet to one of 86 feet. The section taken at the abandoned Black Diamond mine is given below:

		Ft.	In.
Shale		1	4
Coal	*Middle Kittanning*	1	--
Clay shale, black		--	7
Coal		1	11
Clay		--	1
Coal		--	2
Clay		3	--

In Section 10 the Middle Kittanning coal has been mined in the few high hills in which the bed is due, and from local reports it has much the same thickness here as it has at the Black Diamond mine. The bed is present in the eastern and southern parts of Section 11, where it has been mined for many years for a local fuel supply. The following measurements were made at the mine of Henry Wood:

		Ft.	In.
Sandstone, massive		20	--
Shale		4	--
Coal, bony	*Middle Kittanning*	--	3
Coal, good		1	1
Clay		--	4
Coal		1	11

The upper coal bench measures from 1 foot 4 inches to 1 foot 6 inches, the clay parting from 1 to 6 inches, and the lower coal bench from 1 foot 11 inches to 2 feet 2 inches. North of the above locality it is also mined on the land of J. W. Shelton, where the bed has the following structure:

		Ft.	In.
Coal	*Middle Kittanning*	1	2
Clay		--	3
Coal		2	--
Clay, light		--	2
Coal		--	3

The thin block layer of coal below the main bench varies in thickness from 2 to 4 inches, and it is quite free from impurities. The other two coal benches have about the normal thickness for the deposit in this area. The bed is found above cover only along a small stream in the southwestern part of Section 12. No information was obtained in regard to its character here. In Section 13, Greenfield Township, the Middle Kittanning coal is found near the base of the hills along Symmes Creek, and it has been, and is at present, mined at a number of places for the local fuel supply. In the northern part of this section, on land of Henry Hutchison, both the Middle Kittanning and Upper Freeport coals have been mined. The rocks measured are recorded below:

		Ft.	In.
Coal, shaly	*Upper Freeport*	1	1
Clay		--	1
Coal		2	11
Clay and covered		3	--
Sandstone, massive, with parts covered		41	--
Shale		11	--
Covered		3	--
Coal, *Middle Kittanning*, reported thickness		2	--

The interval at this place, from the Middle Kittanning coal to the Upper Freeport coal, is very short, but this appears to be due more to irregularities of the latter than to those of the former, since the Upper Freeport coal at this point lies 177 feet below the Cambridge limestone, while the normal interval separating the two is about 140 feet. In the southern part of Section 13, on the land of Ben Franklin Evans, the bed is mined by drifting, for the neighborhood supply of fuel. The record obtained here is given below:

		Ft.	In.
Sandstone		40	--
Clay, shale, and covered		10	--
Coal	*Middle Kittanning*	1	2
Clay shale		--	4
Coal		2	--
Coal, shaly		2	--

East of the Evans mine, on the land of L. D. Davis, the structure of the bed reported is much the same as that shown in the above section. Along the banks of the small stream in the northwestern part of Section 24, and the northeastern part of Section 23, the Middle Kittanning coal was formerly mined at a number of places. The thickness of the bed is reported to be the same as it is at the Evans mine, on Symmes Creek, to the north. The measurements of the bed at this place also apply in a general way to the thickness of the coal in the central part of Section 15, where it is mined from time to time for local use. In Section 14, the upper bench of coal is generally wanting, and in local areas the main bench is thin. The bed has been mined by drifting on the ridges near the Pumpkintown School, and is reported to have the following structure:

	Ft.	In.
Clay	1	--
Coal, *Middle Kittanning*	1	8

In the northern part of Section 16, the Middle Kittanning coal is represented by only one coal bench, but this has a thickness of about 2 feet, as shown by the following section, taken at the mine of Bonaparte Jenkins:

		Ft.	In.
Coal	*Middle Kittanning*	1	2
Clay parting		--	½
Coal		--	10

In the southern part of the same section the bed is generally thin, and in restricted areas wanting. The deposit is usually thin and unsteady in Section 17, but in local areas, in Section 18, it again has good volume. Measurements of the bed, taken on the land of Wesley Clarkson, are given below:

		Ft.	In.
Shale		4	--
Coal	*Middle Kittanning*	--	8
Clay		--	7
Coal		2	--

The Middle Kittanning coal is poorly represented in Pokepatch Hollow, in sections 19 and 20, and east of this, in Section 21, it is usually represented only by black shales with thin coal bands. Along Dirtyface Creek and its tributaries, in sections 28, 29, 30, 31, and 32, the horizon is above drainage, but the member is thin or wanting. In the southern part of Section 32, on the land of David Howell, this coal was formerly mined by stripping from the bed of Caulley Fork. The thickness is reported to vary from 1 foot to 1 foot 8 inches. The bed appears at drainage level also on Camp Creek, in the western part of Section 36, Greenfield Township, but it is of no importance, as the coal is only about 8 inches in thickness.

Walnut Township.—In Walnut Township the Middle Kittanning coal is above drainage along Symmes Creek, in sections 6, 1, 12 and 7. The bed is somewhat unsteady, but in much of the area it has fair thickness, and has furnished a part of the local fuel supply for many years. On land of Frank Sanders it was formerly mined by drifting, and the bed has the following reported thickness:

		Ft.	In.
Coal, irregular	*Middle Kittanning*	--	10
Clay		--	4
Coal		2	--
Clay		--	1
Coal, bony		--	2

The upper coal bench is reported to vary in thickness from a few inches to 4 feet, and the lower bench from 2 feet to 2 feet 8 inches. Near the bridge across Symmes Creek, on the land of Frank McDaniel, the bed, where exposed for measurement, has the following structure:

		Ft.	In.
Coal	*Middle Kittanning*	1	2
Clay		--	3
Coal		2	1

Along the banks of Symmes Creek, in the northwestern part of Section 7, coal has been mined at a number of places. The bed in this locality is reported by J. G. Williams to have the thickness given below:

		Ft.	In.
Coal, irregular	*Middle Kittanning*	1	--
Clay		--	5
Coal		2	6

The upper coal bench is reported to be variable, both in thickness and in quality, while the lower bench is said to have a maximum thickness of 3 feet, but to average about 2 feet 6 inches.

Perry Township.—The Middle Kittanning coal is above drainage only in one locality in Perry Township, which is along Symmes Creek, in the southwestern part of Section 18, and the northern part of Section 19. On land of Jackcreek Evans, in the latter section, the bed was formerly worked for local consumption. The thickness of the bed is reported by L. D. Davis to be as follows:

		Ft.	In.
Shale		3	--
Coal	*Middle Kittanning*	1	6
Clay		--	4
Coal		2	4

Raccoon Township.—In Raccoon Township the Middle Kittanning coal has been mined in a small way for local use in the vicinity of Centerville, and it is also present along Little Indian Creek, but here the bed is thin and unimportant. Just south of the village of Centerville, on the land of M. E. Beman, the bed was exposed for measurement along the bank of Indian Creek. The record taken is given below:

	Ft.	In.
Shale	3	--
Coal, *Middle Kittanning*	1	5
Clay shale	1	--

Both the Middle Kittanning and Lower Freeport coals have been worked on the land of David Jones, in the northeastern part of Section 30. The following measurements were obtained here:

	Ft.	In.
Coal, *Lower Freeport*	1	3
Clay	1	--
Covered	6	--
Shales, sandy	18	--
Coal, *Middle Kittanning*, reported thickness	2	6

In this locality the thickness of the Middle Kittanning coal is reported to vary from 1 foot 8 inches to 3 feet. North of the village of Centerville the bed is thin, seldom exceeding 1 foot 8 inches in thickness, while along Little Indian Creek the deposit is also thin and in local areas wanting.

Huntington Township.—The next area in which the Middle Kittanning coal is important, is that in western Huntington Township, along Little Raccoon Creek and its tributaries as far down the stream as the Ghee Bridge, which is located in the eastern part of Section 28. Along Keton Run or in the Tomato Valley, as the region is more commonly called, the bed has been worked for many years to supply the local fuel demand. Coal is hauled by wagon from this place to the villages of Vinton, Centerville, and Rio Grande, and to the farm houses in the region for many miles around. The bed is quite persistent here and has good thickness, while the coal is well liked for domestic purposes. Just below the bridge across Little Raccoon Creek, in Section 34, a slope was put down in order to mine the Middle Kittanning coal, but on account of water troubles and other unfavorable conditions it was soon abandoned. The thickness of the bed is reported by A. Sailor to be as follows:

		Ft.	In.
Coal, somewhat bony	*Middle Kittanning*	1	11
Clay		2	--
Coal, good		1	8

Mr. Sailor states that the parting separating the two coal benches varies in thickness from 10 inches to 2 feet, but that it usually has the latter measurement. Formerly coal was mined from the bed of Little Raccoon Creek near the Ghee Bridge, in the eastern part of Section 28. Local parties report the deposit here to be made up of two coal benches, averaging about 3 feet in thickness, with a clay parting measuring about 1 foot. On the farm of Calvin Pierce, in the central part of Section 29, the Middle Kittanning coal has been mined from entries for years. The record obtained follows:

		Ft.	In.
Coal	*Middle Kittanning*	--	4
Clay shale		--	11
Coal, somewhat bony		--	8
Coal, good		2	4

West of this, but in the same section, George Hartsook operates wagon mines on a rather large scale. The record given below was taken here:

		Ft.	In.
Shale, black, with thin coal bands		1	4
Coal, bony	*Middle Kittanning*	3	--
Clay shale		2	--
Coal, good		--	6
Coal, bony		--	4
Coal, good		1	10
Coal, nut, good		--	6

The structure of the bed shown in the above section approaches somewhat that of the great bed found in the Hocking Valley region, excepting here the upper 3-foot bench of coal is bony, and the 6-inch bench of nut coal in the bottom is separated only by a bedding plane and not by a clay or shale parting. However, there is a general similarity between the beds in the two regions in regard to the number and arrangement of the coal benches, and the nature of the partings. The character and appearance of the coal in Gallia County is also similar to that in the Hocking Valley field. In both regions the upper coal benches are the most unsteady in thickness, variable in composition, and local in extent. When only one coal bench is present it is the lower one. At the F. H. Frick mine, in the hollow south of the Hartsook workings, the upper bony bench of coal is wanting, while the lower bench has much the same structure as in the Hartsook mines. The following section taken here shows these features:

		Ft.	In.
Coal, good	*Middle Kittanning*	--	6
Coal, bony		--	3
Coal, good		2	2

In parts of Section 30, the upper coal bench, having a thickness of about 3 feet, is of good quality, and it is the one mined for local use. The section obtained at the mine of Evan F. Evans shows the relation of the coal benches and the thickness and character of the partings:

		Ft.	In.
Coal, good, no bone	*Middle Kittanning*	3	--
Coal, bony		--	3
Clay, light, plastic		6	--
Shale, black		1	4
Coal, good		2	8

Along Little Raccoon Creek, in the southeastern part of Section 20, several mines have been operated on the land of Eliza Ann Chavies. The section obtained at the mouth of an abandoned mine follows:

		Ft.	In.
Sandstone, massive		6	--
Disconformity.			
Clay		1	--
Coal, somewhat bony	*Middle Kittanning*	2	2
Clay		--	6
Coal, bony		--	10
Clay		--	1
Coal, good		2	8

The lower surface of the sandstone above the coal is very irregular, and an erosion plane here is quite evident, for the sandstone in places in the entry replaces the 1 foot of clay and the 2 feet 2 inches of coal below the clay. The upper coal bench also varies much in thickness, but the middle and lower benches are very steady. North of this near Mrs. Chavies' home the structure of the bed is considerably different from that shown above. The measurements made here are given below:

		Ft.	In.
Bone coal, with clay and shale partings	*Middle Kittanning*	2	--
Coal, somewhat bony		1	1
Coal, good		2	1

The Middle Kittanning coal is above drainage in the western part of Section 21, Huntington Township, but the bed, although formerly worked at a few places, was poorly exposed for measurement. It is reported to vary from 2 to 4 feet in thickness. A section obtained on the land of William Cardwell in the northwestern part of Section 21 is given below:

		Ft.	In.
Bone coal with shale partings	*Middle Kittanning*	--	10
Coal, good		--	5
Bone coal with shale partings		--	7
Coal, good		2	4
Clay, siliceous		2	--

In Section 19 a heavy blossom of the bed was seen along the road that crosses Little Raccoon Creek, and then leads to the ridge south. The bed was formerly worked by drifting on the hill west of this exposure, and the coal is reported to be of excellent quality and to have good thickness. This deposit was also mined on the land of R. C. Radekin in the southeastern part of Section 18, where the thickness of the bed is stated to be approximately 4 feet. In the northern part of this section, along the Little Raccoon Valley, the blossom of the coal was observed at a number of places, but the surface features indicate that the bed in this locality is generally thin. The interval from the Middle Kittanning coal to the Upper Freeport coal measures 89 feet at the mine of B. Snyder.

The bed has been opened on land of T. J. Jones in Section 17, Huntington Township, but due to a poor roof it was not mined to any extent. The coal measures 4 feet at this place and has a tender shale roof.

Along Spring Run, in Section 8, the Middle Kittanning coal is found near drainage level, but the bed is generally thin, and in places it is wanting. The blossom of the bed was seen at several places along the small tributary of Little Raccoon Creek in Section 7. The deposit is usually thin, but on the W. L. Huntley farm it is reported to have a thickness of 3 feet. The Middle Kittanning coal is also due along the Raccoon Valley from the northern line of the county to south of the village of Ewington, but the bed is nearly completely replaced by the massive sandstones that make up the interval.

Extent Under Cover

The prospects for productive fields of Middle Kittanning coal under cover in western Gallia County are far more encouraging than they are for the other coals that outcrop in the area. The conditions favor a covered field in central and southern Huntington Township, for the bed is quite steady and has good thickness where it dips below drainage. Where exposed along Little Indian and Indian creeks in western Raccoon Township it is thin and patchy, but as the bed along Little Raccoon Creek in Huntington Township thickens when traced eastward it may also do the same here; in fact this is the general tendency. In southeastern Madison Township, Jackson County, the bed is best represented near Centerpoint, where it passes below drainage. This is the condition also found along Symmes Creek in northeastern Greenfield Township, Gallia County, for here, where it disappears from view, the bed has good volume and is quite persistent. These features point to an area of good coal under cover in western Perry and southwestern Raccoon townships. Along Symmes Creek in northwestern Walnut Township there is found another area of good coal, which a short distance west is generally thin and often wanting. The surface conditions of the Middle Kittanning coal in western Gallia County thus indicate that there is a belt below cover in which the coal bed is moderately continuous at least, and in which the volume should equal that held where the bed disappears below drainage. This belt extends from western Walnut Township across Perry and Raccoon townships, and ends in central Huntington Township. This general thickening of the Middle Kittanning coal in its extension eastward is also well defined in southern Lawrence County, since the maximum volume of the bed here is found where it goes below cover in the Sheridan district which is on a line with the belt traced in Gallia County.

Mining and Economic Features

The Middle Kittanning coal has features unfavorable for producing fuel at a low cost by the methods of mining in common practice. The bed, when well developed, is made up of two or more coal benches separated by soft clay or by carbonaceous shale partings, which vary in thickness from one inch or less to many feet. Further bone coal bands often divide the coal benches into layers; hence much care is required in mining to keep the fuel free from this deleterious material. The clays and shales interstratified with the coal are usually soft and more or less plastic, and when loosened by the pick or by shooting they crumble or break into a relatively fine material, which is hard to remove from the nut and slack coal. When only small amounts of clay are present in coal which is exposed to the weather in transit or in storage, the clay disintegrates, and so whitewashes the fuel, which then has an unsightly appearance, although it is but little damaged. As these parting materials must be handled in mining the coal, their effect on the expenditure of unproductive labor should be duly considered. In new entry work they are usually removed from the mine, while in room work, if the partings are not too thick, the materials may be thrown back or as the miners say "gobbed." In either case, however, this material is handled. The average thickness of the parting between two coal benches, which are commonly present, is 5 inches, and the yield of waste material from it amounts to approximately 585 pounds per square yard of surface. This is about one-fourth the weight of the coal in a like area in which the two coal benches have a mean thickness of 3 feet 1 inch, since the yield of coal is about 2,255 pounds. The thickening of the parting soon makes the mining of the coal prohibitive where only the fuel is utilized. Another feature along this same line is the character of the roof in a part of the field in Gallia County. In some of the best coal areas the roof material is either a soft clay or a tender shale, from

1 to 4 feet in thickness, above which is found a massive sandstone. Through the action of percolating waters the clay or shale soon loosens from the sandstone above and becomes a menace in mining. If the shale is a few feet in thickness it may be held up by thorough posting, but if the stratum is thin it must be removed, for it will break down over the posts and caps. Clays are very difficult to hold under any ordinary system of mine posting. Water readily softens them until they will not bear their own weight, much less that of the materials above. They crumble rapidly when exposed to a circulation of air, and they break easily along the slickensides planes, thus producing "kettle bottoms," especially dreaded by miners. For safety these clays must be taken down. The clays and the shales also have good ceramic qualities, and should be utilized in the manufacture of commercial products. In a number of localities in Gallia County the soft clays and tender shales of the roof and partings with the clay below the coal bed will furnish, when the coal is mined in a large way, a sufficient amount of material to supply a ceramic plant of average capacity. The best economy in coal mining in this area will be obtained only when the clays are put to such subsidiary uses. The impure benches of coal, often found in the deposit in the Tomato Valley region, Huntington Township, and also at other places, have thicknesses from a few inches to 3 feet. Bone coal partings a few inches in thickness are also a common feature of the productive field. If used in the burning of clay ware, this bone coal, otherwise of no value, with also the low-grade nut and slack coal, may yield a fair reward for the labor expended in its mining although under the present conditions of operating it is an expensive waste. The clay and clay shale partings have a value, however, as they give some aid in mining the coal. Either the clay or the shale is easily cut by the pick or by the cutting machine. By cutting in them the full thickness of the coal is saved. In low coal, also, the increased height of the mine due to the partings gives more comfort in working the bed and more ease in hauling the fuel.

The Middle Kittanning coal has some mining features in its favor. The coal, although not dense, is quite firmly bonded, therefore it mines in good sized lumps, with only a small percentage of fine coal. This is also favored somewhat by the division of the deposit into benches and by the separation of the benches often by bedding planes. The coal is moderately free from sulphur balls, which cause trouble in boring holes for explosives. The partings also tend to neutralize the serious effects of the explosions on the roof of the mine, especially when the coal is shot off the solid, as the miners say. The bony layers are usually either at the top or the bottom of the coal bench; hence they may be separated easily from the good coal. The firm, lumpy character of the Middle Kittanning coal is a feature of importance in shipping and handling the fuel, as screened coal for the general trade must be able to withstand severe usage without producing an appreciable loss from its reduction to fine material.

On the whole, the mining conditions of the Middle Kittanning coal in Gallia County are not the best; therefore the bed should not be attacked blindly, but it should be studied thoroughly before large operations are attempted. The knowledge of all the various phases of the bed in any given locality may eliminate difficulties otherwise vital to successful mining. The value of the associated beds should also be duly considered.

The quality of the Middle Kittanning coal in Gallia County is on a par with that found for the fuel in this great deposit elsewhere in Ohio. It is high in volatile matter, therefore it is classed as a free-burning coal. In this respect it ranks between the Lower Kittanning and Upper Freeport coals, but much below the Quakertown and Mercer coals of the Pottsville formation. The amount of volatile matter in the fuel, although varying somewhat in coals from different localities, averages about 38 per cent. Since the volatile matter is high, the fixed carbon is necessarily low. This component is present in amounts varying from 46 to 53 per cent, but averaging about 48 per cent. In this coal the hydroscopic water or natural moisture is also rather high, since it runs to about 7 per cent. The ash, amounting to about 8 per cent, is clay-like in character and light gray in color. It clinkers but little unless subjected to severe heat or to highly reducing conditions. The Middle Kittanning coal in Gallia County averages rather high in sulphur. The pyrite, or rather marcasite, for this is the form in which the sulphur is most often present, is distributed mainly in thin irregular sheets along the bedding planes, or along the bands of "mother coal". The lower, or main bench of coal is usually less contaminated with this objectionable impurity than the upper benches are. The deposit, as a whole, contains from 2.5 to 3.5 per cent sulphur. The Middle Kittanning coal has a heating value of about 12,400 B.t.u. The following analysis shows the general quality of the bed in Gallia County:[1]

Mine of Black Diamond Coal Company, Section 9, Greenfield Township, Gallia County. The sample was taken from a fresh face, well under cover, and measured 6 by 4 inches. The upper bench is less pure and varies much in thickness. The thin coal at the bottom is not mined and was rejected in sample. The latter was taken by D. D. Condit in November, 1906.

Chemical analysis and calorific value of sample

Ultimate		*Proximate*	
Carbon	65.71	Moisture	8.08(a)
Hydrogen	5.48	Volatile matter	37.53
Oxygen	15.47	Fixed carbon	45.87
Nitrogen	1.18	Ash	8.52
Sulphur	3.64		
Ash	8.52		100.00
	100.00		

Calorific value { Calories 6,717
B. t. u. 12,091

(a) Moisture in air-dried sample from 2½ to 3 per cent.

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[1] Geol Surv. Ohio, Fourth Ser., Bull. 9, p. 203.

The above analysis shows that the Middle Kittanning coal is a very good general purpose fuel. It is well liked for domestic use as it ignites quite readily and makes a lasting fire, especially if the lumps are laid so that the bedding planes of the coal are horizontal to the grates. During combustion the coal produces some soot, the amount of which is too small to be troublesome. The ash is light or powdery, hence it passes through the grates without seriously affecting the draft. The lumpy character of the fuel is also liked by the housewife. The Middle Kittanning coal is highly regarded for steaming purposes on account of its free-burning character, of its heating qualities, and of the non-clinkering nature of its ash. The cementing value of this coal is low; hence it cokes but little in the beehive oven. If used in moderate amounts with some rich coking coal in retort ovens, the coal may have some coking value, although at present this point has not been determined by practice or even by experiment. Many coals that make an unsatisfactory product in the beehive ovens coke very well in the modern retort ovens. Since the latter method of coke making is rapidly replacing the former method, and since the coke question is becoming more important each year in Ohio, the value of coal beds for this purpose in any important coal field should not be overlooked. The Middle Kittanning coal in Gallia County is quite high in sulphur, in fact above the limit for coke making, but a part of this can be removed by crushing and washing. The lower or main coal bench is lower in this impurity than the upper benches are. The Middle Kittanning coal, although not ranking high, is one of the standard coals of Ohio for the manufacture of artificial gas. It is also a very good fuel for ceramic purposes. As it burns freely, the temperature desired in the kiln may be readily obtained. The flame produced by the combustion of the coal in the kiln arches is of sufficient length to completely envelop the entire body of ware in the kiln. This impinging of the flame on the surface of the ware produces the fine color and finish desired. The non-clinkering nature of the ash, except at high temperatures, is also an advantage in the burning of clay products. The Middle Kittanning coal, when considered from various standards, is one of the most important mineral assets of Gallia County.

LOWER FREEPORT CLAY

The clay associated with the Lower Freeport coal has small economic value, for the deposit is usually thin and unsteady. The thickness of the bed varies from about 1 foot to 5 feet, but the average thickness will not exceed 2 feet. The clay is everywhere siliceous in character, yet it has sufficient plasticity for use in the general field of ceramic work. In local areas the deposit contains considerable concretionary matter in the form of ferrous carbonate, which is troublesome in clay working. Profitable utilization of the bed is scarcely possible under the present status of the ceramic industry in Ohio, unless other factors, especially favorable, are at hand.

LOWER FREEPORT, HATCHER, OR No. 6a COAL

Stratigraphy and Extent

When the rock strata in southern Ohio are considered in ascending order, the Lower Freeport coal is the next well recognized fuel bed above the great Middle Kittanning coal. In Lawrence County, the Lower Freeport deposit is locally called "Hatcher" coal. In Gallia County this bed is found on an average about 24 feet above the Middle Kittanning coal or approximately 53 feet below the Upper Freeport coal. These intervals are usually made up of massive sandstones and they contract or expand very erratically. The distance from the Lower Freeport coal to the underlying Middle Kittanning coal varies from about 12 to 45 feet, while the distance from the former to the Upper Freeport coal expands irregularly from 30 to 60 feet. The bed in this area is difficult to trace as it is so often wanting, and as the intervals to other well known members are so extremely variable.

The horizon of the Lower Freeport coal is above drainage in Greenfield, western Walnut, western Perry, northwestern Raccoon, and western and northern Huntington townships. The bed in this area is made up of a single coal bench, which seldom has sufficient volume for drift mining under the present system of operation.

Walnut Township.—In western Walnut Township, the bed where present has a thickness varying from a thin slaty band to about 1 foot 8 inches, but the usual measurement found is from 6 to 10 inches. A composite section, taken in the vicinity of McDaniel in Section 1, west, Walnut Township, and showing the intervals to other important members, is given below:

Horizon of *Upper Freeport* coal.	Ft.	In.
Clay, light and mottled	5	--
Sandstone, shaly	13	--
Clay shales	4	--
Shales with nodules of bastard limestone	1	--
Shales, gray	4	--
Clay shales	3	--
Shales, sandy	5	--
Sandstone, shaly	7	--
Coal, *Lower Freeport*	--	8
Clay shales	2	--
Shales and shaly sandstones	18	--
Sandstone and covered	17	--
Coal, *Middle Kittanning*	3	6

The Lower Freeport coal is present in a few localities in Section 6, and, where measured, the bed is from 6 inches to 1 foot in thickness.

In sections 5, 7, 8, and 12, the coal is generally replaced by a massive sandstone, but, where present, it has not attracted attention even for local use. East of the village of Waterloo, in sections 30 and 31, Walnut Township, the Lower Freeport coal is found about 35 feet below the thick deposit of Upper Freeport coal. In this locality the bed is quite constant, and has a thickness varying from 6 inches to 1 foot 6 inches.

Greenfield Township.—In Greenfield Township, the Lower Freeport coal is generally wanting, and, where present, it has small value. Near the head of Camp Creek, in Section 34, coal has been mined by stripping from the stream bed, where the deposit is reported to have a thickness of about 1 foot. The blossom of the coal is also exposed at other places along the valley in sections 35 and 36. Along Dirtyface Creek and its eastern tributaries the coal is also present in restricted districts, while north of this, on the ridges between Pokepatch Hollow and Lefthand Fork, the deposit is generally replaced by thick sandstones.

The horizon of the Lower Freeport coal is also above drainage along Symmes Creek and its tributaries in western Perry Township, but coal of value was not found.

Raccoon Township.—The Lower Freeport coal is best developed in western Raccoon Township, near the village of Centerville, where it has yielded a part of the local fuel supply for many years. In this locality the bed lies very close to the Middle Kittanning coal. On land of David Jones in Section 19, the strata, exposed at the mouth of an old mine entry, measured as follows:

	Ft.	In.
Shale	--	6
Coal, *Lower Freeport*	1	10
Clay	1	--

Under heavy cover in this locality, Mr. Jones reports the coal to have a thickness from 2 feet 6 inches to 3 feet. The bed is not broken by partings and has about the same composition throughout the mine. East of the above, in Section 30, but on another tract of land belonging to Mr. Jones, both the Lower Freeport and the Middle Kittanning coals have been mined in a small way. The section obtained is given below:

	Ft.	In.
Coal, *Lower Freeport*	1	3
Clay	1	--
Covered	6	--
Shales, sandy	18	--
Coal, *Middle Kittanning*, reported thickness	2	6

Near by, the interval between the two beds is even less than that shown in the above section. The deposit has also been mined along the small stream south of Indian Creek in the western part of Section 29. The coal was not exposed for measurement at this place, but it is reported to have a thickness of about 2 feet. Along a small stream in the southeastern part of the same section the bed was formerly mined in rather a large way by drifting. The thickness of the coal in these mines is reported to vary from 1 foot 6 inches to 4 feet. In some parts of the mines, shales intervene between the coal and the overlying massive sandstone, thus making mining somewhat dangerous. North of Indian Creek, in the same section, the bed has been worked on land of D. N. Williams for local use. The Middle Kittanning coal is also present here and has been mined by stripping. The section obtained shows the relation between the two deposits and the measurements recorded are given below:

	Ft.	In.
Coal, *Lower Freeport*	2	6
Sandstone	12	--
Coal, *Middle Kittanning*	1	6

Mr Williams reports that the Lower Freeport coal is very unsteady and that it varies in thickness from 1 foot 6 inches to 4 feet. The thickness of the shale above the coal is also variable. The clay above the coal is wanting in parts of the mine, while in other parts it expands to about 3 feet. The coal bed also varies in thickness from 2 to 3 feet. In the western part of Section 28, the deposit has been mined at a few places along the south bank of Indian Creek.

The Lower Freeport coal has been mined near drainage level on Little Indian Creek in Section 16, on lands of O. L. Evans, D. D. Thomas, and L. A. Swain. Here the deposit is reported to have a thickness from 1 foot 6 inches to 1 foot 8 inches. The thin blossom of the bed is also exposed at other places farther up the stream but the coal has not been mined.

Huntington Township.—In Huntington Township the Lower Freeport coal is present at a few points along the valley of Little Raccoon Creek and its tributaries. Where exposed, the member is marked by only a few inches of coal, or by a soot streak, with a siliceous clay below. In this area the deposit is found from 25 to 45 feet above the Middle Kittanning coal. The bed is also due along Raccoon Creek, but the massive sandstones have so completely replaced it that only mere traces of the deposit are found.

Economic Value

The Lower Freeport coal adds but little to the mineral wealth of Gallia County. The deposit has sufficient thickness to be worked at present by drift mining in only one locality in the county, which is along the valley of Indian Creek east of the village of Centerville. It was not regularly mined at any place when this region was visited (1915), but it may yet contribute a small supply of fuel for local needs, since the field has not been exhausted. The bed often has objectionable mining features which retard its utilization. The most serious of these is the variability of the coal bed itself, for the thickness may change in a short distance from a few inches to 3 or 4 feet. This causes much unproductive labor in driving entries from one pocket of coal to another. In local areas the character of the roof is often objectionable, because the roof materials are tender shales or soft clays. These are dangerous to the lives of the workmen. The deposit, however, has some good qualities. It is, with few exceptions, made up of a single coal bench which is quite free from shaly impurities. The coal is quite hard and firm; hence it mines in lumps with only a small loss of fine material.

The quality of the Lower Freeport coal much resembles that of the Middle Kittanning coal, except that it has a larger content of volatile matter. In restricted areas its appearance indicates that it is about midway between an ordinary bituminous and a true cannel coal. It is an oily free-burning fuel with good heating properties. The ash is moderate in amount and clinkers slightly.

CLAY AND SHALE ON THE UPPER FREEPORT COAL HORIZON

The Upper Freeport clay, the position of which is directly below the Upper Freeport coal, is far more persistent than the coal bed, but in many localities it is also wanting. Where present, however, it is not always of ceramic quality, since concretionary matter and finely divided oxides of iron are present in amounts sufficiently large to cause serious trouble in manufacturing the clay into a marketable product. This clay, with few exceptions, is very siliceous in character, and, when underlain by sandstone, which is the common bedrock, it gradates into this material, with no definite line of demarcation. Although lime and magnesia, principally in the form of carbonates, are always present in the clay, the amounts are seldom enough to exclude the clay from the ceramic field. The thickness of the bed varies from 1 to 10 feet, but the average measurement is about 3 feet 6 inches. The plasticity of the clay is moderately good; hence no serious difficulty should be encountered in manufacturing it into ware. This clay, except when charged with concretionary and comminuted fluxing components, should burn to a strong body with no serious defects. The material is best suited for the manufacture of the more common classes of clay products, such as common and face building brick, paving blocks, and fireproofing. The shale found directly above the coal in some localities is also fitted for the production of building and paving brick.

UPPER FREEPORT COAL

The deposition of the Upper Freeport coal closes the record of the series of coals and clays which are separated by less valuable deposits of shales, sandstones, iron ores, and limestones, laid down during Allegheny time. Since this coal underlies shale or sandstone of Conemaugh age, it marks the line separating these two great formations of the Pennsylvanian series. The outcrop of the Upper Freeport coal forms a belt that crosses the state from Columbiana County on the east to

Upper Freeport or Waterloo coal at the mine of Noah Webster in Walnut Township, Gallia County.

Lawrence County on the south. From the latter place it crosses into Kentucky, where it is known as the Zelda or No. 9 coal. Although the bed is very patchy in this state it has yielded a large amount of fuel and holds a good supply for future needs. In western Gallia County, especially in what is known as the Waterloo or Flag Springs field, this member, due to the volume of the bed and to the excellence of the fuel, early attracted attention for the local fuel supply, and has been worked constantly for many years. In Huntington Township, also, this bed contributes fuel for domestic needs.

Stratigraphy and Extent

In Gallia County the Upper Freeport or Waterloo coal lies about 53 feet above the Lower Freeport coal or about 78 feet above the more persistent Middle Kittanning coal, which is thus a better bench mark for reference. Although the structure of the bed varies from place to place, the general features of the deposit are much the same when present in good volume. The greatest changes are noted in the character and arrangement of the upper coal benches. The Upper Freeport coal has from one to three coal benches, separated by clay or shale partings. The lower coal bench is the one of prime importance, since it is far more persistent than the ones above, and since it surpasses them to a marked degree in volume and purity. This coal bench, in the area in which the Upper Freeport coal is of value in Gallia County, varies in thickness from 2 feet to 4 feet 6 inches, and it has a mean measurement of 3 feet. The clay parting separating the lower coal bench from the one above averages only about 3 inches in thickness, but in some localities the middle bench of coal is wanting, then the clay coalesces with the parting above and measures 1 foot or more in thickness. The thickness of the middle coal bench, often shaly, varies from 2 inches to 1 foot 6 inches, but the good coal in it seldom exceeds 10 inches. In a part of the Flag Springs field the second parting is about 5 inches in thickness, and the upper or third coal bench, usually somewhat impure, has a mean thickness of 1 foot 3 inches. These features will be brought out in more detail as the deposit is traced across the county.

The Upper Freeport coal in Gallia County is represented only by isolated patches of coal, the areas of which are relatively small. It is far more uncertain than the Kittanning coals below. The coal may go out completely, in passing from one hill to another, or from one point on the same hill to another only 100 yards or so distant. Usually not even a stain is present to mark the horizon. In a few localities, the Upper Freeport coal is replaced by the massive overlying Mahoning sandstone, but in most of the area this is not the case, for the coal is wanting, even when the beds above are soft ferruginous clays or fine-grained shales. When thus placed, there is no apparent disconformity along the horizon. When all the factors are considered, they suggest, rather, that the bed was not laid down in a continuous sheet, but that it was deposited only in local basins, and that the coal in parts of these isolated areas was later removed by the action of the currents which laid down the Mahoning sandstone, also local in extent.

The horizon of the Upper Freeport coal passes above the summits of the highest knobs in the northwestern part of Greenfield Township, but in the southwestern part it is present along the main ridges at an elevation of approximately 860 feet above tide. Owing to the dip of the rocks to the east, the bed is well down on the hills in the eastern part of this township. The elevation in the northeastern part is about 760 feet, while that in the southeastern part is about 720 feet. The bed is generally present along Symmes Creek and well towards the headwaters of its tributaries in western Walnut Township. The height of the deposit above tide here is from 600 to 740 feet. The horizon of the Upper Freeport coal is found close to drainage level in the western part of Perry Township. Along Symmes Creek and its tributaries, the elevation of the bed is from 640 to 740 feet, while along Fork Creek, and another small tributary of Raccoon Creek, north of this, its position above tide is from 600 to 640 feet. In Raccoon Township, the place of the Upper Freeport coal is above drainage in practically all of the territory except small areas along Raccoon Creek. The elevation of the bed in the western part of the township is from 740 to 780 feet, while in the eastern part it is from 580 to 620 feet. The rise of the rock strata, in passing northward places the horizon of the coal bed above drainage in all of Huntington Township. Measuring from tide, the elevation in the western part is between 780 and 820 feet, while along Raccoon Creek, in the eastern part, it is between 620 and 700 feet.

Walnut Township.—Since the Upper Freeport coal in southern Ohio gained its reputation from the Flag Springs or Waterloo field, in western Walnut Township, this region will be treated first. The outcropping conditions in Section 31 give little promise of much coal of value, while in Section 30 the prospect openings show only thin coal or dark carbonaceous shales. The Upper Freeport coal has its maximum development however north of this in Section 19. In this region the bed has excellent volume, and the fuel also is of exceptional quality. The structure of the deposit at the mine of Noah Webster is shown by the following record:

		Ft.	In.
Shale		6	--
Coal, somewhat impure	*Upper Freeport*	1	5
Clay shale		--	4
Coal		--	7
Clay shale		--	2
Coal		4	6

The middle and lower benches of coal are quite free from impurities, while the upper bench contains some thin bands of shale, which injure its sale. Since the shale above this coal bench is somewhat tender, the coal is left to form the roof of the mine. This coal bench varies considerably in thickness in different parts of the mine, while the middle coal bench in places thins to 2 inches. The lower or main coal bench in this locality is seldom less than 3 feet or more than 5 feet in thickness. At the mine of Jason Strait, in the western part of the same section, the middle bench of coal is wanting, but the upper and lower benches have much the same thickness as they have in the Webster mine. A composite section measured here follows:

		Ft.	In.
Limestone, *Cambridge*		1	6
Coal blossom, *Wilgus*		1	6
Shales, part mottled		19	--
Limestone, flinty, upper *Brush Creek*		4	--
Shales and covered		6	--
Sandstone, massive		32	--
Clay shales and covered		21	--
Shales, sandy, gray		30	--
Shales, light		2	--
Coal, shaly	*Upper Freeport*	1	3
Clay		--	9
Coal		3	6
Clay, shales, and covered		35	--
Coal, *Lower Freeport*		--	6

The Upper Freeport coal has been mined quite extensively along the western and northern bank of the little stream in the western part of Section 20. Along the opposite bank the bed is much thinner and in places wanting, although where it passes below drainage the coal has good volume. Measurements taken in a mine on land of T. J. Neal are given below:

		Ft.	In.
Shales		7	--
Coal	*Upper Freeport*	1	2
Clay shale		--	7
Coal		--	7
Clay shale		--	3
Coal		3	10

The deposit is poorly represented in Section 18. Where it is exposed, the bed is thin or shaly, while in part of the area it is wanting. This is the condition also of the bed exposed along the small stream in the northern part of Section 17, but north of this in Section 8, coal was formerly mined in a small way. E. L. McDaniel reports that on his property the lower coal bench has a thickness of 3 feet, while the upper bench measures about 1 foot 6 inches. He also states that the two coal benches are separated by 1 foot 6 inches of clay. In sections 7 and 12 the horizon, where exposed, is marked by siliceous clays with only a smut streak of coal at most. Coal of value was not found at any place on this horizon in sections 1, 6, 5, or 4.

Perry Township.—In this township the Upper Freeport coal was not found in good development along Symmes Creek or its tributaries, except in the northern part of Section 18 and the southern part of Section 7. Here there is a small area of coal, which appears to be a part of the local field in sections 12 and 13, Greenfield Township. The bed was mined for several years by drifting on the land of William M. Jones in the northwestern part of Section 18. The record obtained follows:

		Ft.	In.
Coal	*Upper Freeport*	1	6
Clay		--	6
Coal		2	--

In the southern part of Section 7, on the farm of James Davis, the deposit was also worked at one time. Mr. Davis states that the upper bench of coal is about 1 foot in thickness, while the lower bench varies from 2 feet to 2 feet 6 inches. He reports also that in this area the parting expands from 4 inches to 1 foot in thickness. The deposit, however, is quite local in extent for good coal has not been found elsewhere in the northern part of Perry Township, although the horizon is above drainage in other sections.

Greenfield Township.—Although the horizon of the Upper Freeport coal is above drainage in all of Greenfield Township, the bed was found with sufficient volume for mining in only one locality, which is in sections 12 and 13. In most of the area it is completely wanting or represented by siliceous clays or by thin layers of impure coal. In Section 12, on the farm of H. T. Lambert, the Upper Freeport coal is mined for local needs. A section obtained follows:

		Ft.	In.
Coal, somewhat rough	*Upper Freeport*	1	2
Clay		--	2
Coal, good		3	--

The lower bench of coal in this mine varies from 2 feet 6 inches to 3 feet 4 inches in thickness, while the upper bench is more constant. From 1 to 4 inches of good cannel coal is present near the middle of the lower bench of coal in parts of the mine. This productive area extends south into Section 13, where the bed was mined for several years on the land of Henry Hutchison, and on the adjoining farms also.

Raccoon Township.—The surface conditions indicate that the Upper Freeport coal is poorly represented in Raccoon Township. In some parts of the area it is completely replaced by massive sandstones, while in other parts the horizon is marked only by thin coal layers or by dark carbonaceous shales. However, this does not prove that the deposit at no place has good volume, but rather that, if such pockets of coal exist under heavy cover, their areas are relatively small.

Huntington Township.—In the northwestern part of Huntington Township there is another small field in which the Upper Freeport coal has good volume, and in which the bed is mined for local use. Measurements taken at the mines of Edward Snyder, in Section 18, show the structure of the bed and the interval to the Middle Kittanning coal below. The record follows:

		Ft.	In.
Coal, bony, cannel nature	*Upper Freeport*	--	2
Coal, good		3	1
Clay, siliceous		4	--
Covered		10	--
Sandstone		10	--
Covered		6	--
Sandstone, massive		32	--
Sandstone with parts covered		27	--
Coal blossom, *Middle Kittanning*		1	--

The main coal bench is reported to be much thicker in parts of the mine than it is shown to be in the above section; however, the thick coal is very local in extent. The interval between the main coal bench and the massive overlying sandstone, which is the real roof of the bed, expands erratically from a few inches to as much as 6 feet. This interval is made up of clay shales with a layer of very impure coal, the thickness of which is from 1 to 2 feet. This impure layer of coal, which corresponds to the upper bench of coal in the Waterloo field, is made up of thin bands of coal, shale, and sandstone. The relation of the two coal benches is shown in the following section taken at the mine of Emmett Oiler, which is located in the northern part of Section 18:

		Ft.	In.
Sandstone, *Mahoning*		21	--
Clay, dark		--	4
Coal, bony	*Upper Freeport*	1	2
Coal, good		3	6
Clay, siliceous		3	--

In this locality the lower bench or good coal varies in thickness from 1 foot 6 inches to 5 feet 6 inches, but the average measurement is about 3 feet 6 inches, while the impure layer, often wanting, has a maximum thickness of about 2 feet. In the southern part of Section 7, on the land of W. L. Huntley, the deposit is worked also by drift mining. The measurements taken in his mine are given below:

		Ft.	In.
Shale, gray		4	--
Coal, impure	*Upper Freeport*	--	10
Coal, good		3	7
Clay, light, siliceous		3	--

In this locality the deposit is reported to have a maximum thickness of about 6 feet. In the northwestern part of the same section the Upper Freeport coal again has good volume and has been worked for local use. On the ridge north of the residence of W. F. White, the bed where measured in an old mine has a thickness of 4 feet 2 inches North of this in the southern part of Section 6, on the farm of George Snyder, the following record was obtained:

	Ft.	In.
Shale, gray, sandy	12	--
Coal, *Upper Freeport*	5	10
Clay, siliceous	3	--

This field in northern Huntington Township extends northward into Wilkesville Township, Vinton County, where, especially in the vicinity of the Cooney School, the bed has excellent volume and purity. In the remainder of Huntington Township the Upper Freeport coal where exposed along the outcrop is either thin or wanting. In fact the prospects for locating other areas of good coal with sufficient volume for drift mining are very poor. The bed has no value in that part of Morgan Township where it is above drainage level.

Economic Features

The areas in Gallia County in which the Upper Freeport coal is known to have good volume will not exceed 3 square miles. The productive territory, however, is less than this, for in all of the small isolated fields the bed is subject to wants or to thin coal. A much safer estimate of the areas in which the bed, considering only the thickness of good coal, has an average measurement of 3 feet 6 inches is from 1,000 to 1,200 acres. The yield of fuel on 1,000 acres, counting the specific gravity 1.31, the thickness of the bed 3 feet 6 inches, and the amount available in mining 60 per cent, is approximately 3,745,000 tons. Since these fields have been worked for many years in a very wasteful way, the total amount of fuel yet available for future needs will probably not exceed 2,000,000 tons. The mining features of the Upper Freeport coal, although not the best, are usually favorable for safety in working and for economy in production when the operation is carried on in a systematic way. Above the upper bench of coal in most of the territory there are present a few feet or more of soft clays or tender shales which are held up with difficulty. If the upper coal bench, which is usually too impure to be of value, is allowed to remain for the roof of the mine, and is properly supported by posts, the clays and shales above are not especially troublesome or dangerous. In some localities the overlying stratum is a massive sandstone, and then of course the roof is strong and safe.

The Upper Freeport coal is a high volatile fuel, but is not so free-burning as the Kittanning coals below. It is a bright lustrous coal, and is quite free from "mother coal" or shaly impurities. As the fuel is quite fragile or tender, it is not well suited to withstand severe handling. The composition of the Upper Freeport coal in Gallia County is shown by the following analyses:

Sander's Mine, Section 17, Walnut Township, Gallia County. Lower bench only sampled, the upper bench not mined. The mine had not been worked for three years but the coal appeared fresh. The surface of the coal was cut off before sampling. Sampled by E. E. Somermeier in August, 1902.

Chemical analysis and calorific value of sample

Ultimate		*Proximate*	
Carbon	63.48	Moisture	7.62
Hydrogen	5.19	Volatile matter	32.85
Oxygen	15.85	Fixed carbon	47.14
Nitrogen	1.28	Ash	12.39
Sulphur	1.81		
Ash	12.39		

Calorific value { 6,371 calories
11,468 B. t. u.[1]

Samples from the benches of coal in the mine of Noah Webster in Section 19, Walnut Township, are given below:

No. 1. From the upper 9 inch seam.
No. 2. From the middle 9 inch seam.
No. 3. From the lower or 4 feet 3 inch seam.

	No. 1	No. 2	No. 3
Specific gravity	1.307	1.295	1.309
Water	4.05	6.00	5.15
Ash	7.60	4.65	4.60
Volatile matter	34.35	31.20	29.65
Fixed carbon	54.00	58.15	60.60
Total	100.00	100.00	100.00
Sulphur	1.15	0.86	0.82
Sulphur remaining in coke			0.07
Percentage of sulphur in coke			0.11
Gas per lb., in cubic feet	3.46	3.07	3.24[2]

The analysis of the sample of Upper Freeport coal from the Sander's property represents the character of the coal along the border of the Flag Springs field, while that of the sample from the Webster farm represents the character of the fuel near the center of this area, or where the deposit is at its best. The average character of the deposit in Gallia County is between these results.

The Upper Freeport coal is well liked for domestic and steaming purposes. It is a lasting fuel, for the fixed carbon is slowly consumed. It makes a good heat and produces only a small amount of soot. The ash, which is light gray in color, clinkers somewhat, especially if subjected to reducing conditions. The Upper Freeport coal is one of the few coking coals of southern Ohio. Although its cementing value is only moderately high, it makes coke of fair quality in the beehive oven. In the retort oven the better grades of this coal should yield approximately 64 per cent coke. The sulphur in the coal occurs principally in the form of the mineral marcasite, which is irregularly distributed throughout the bed in thin lenses or in nodular masses. Owing to the difference in the specific gravities of coal and marcasite, proper sizing and washing of the coal will remove a large percentage of this deleterious material. Further, the amount of the sulphur is decreased during the coking for about one-half of it passes off in the gases. Under good practice of coke making, the sulphur in the product should be reduced below the limit demanded for standard coke. The rapid increase in the erection of retort ovens makes the subject of moment, especially in Ohio, where but few coking coals are found.

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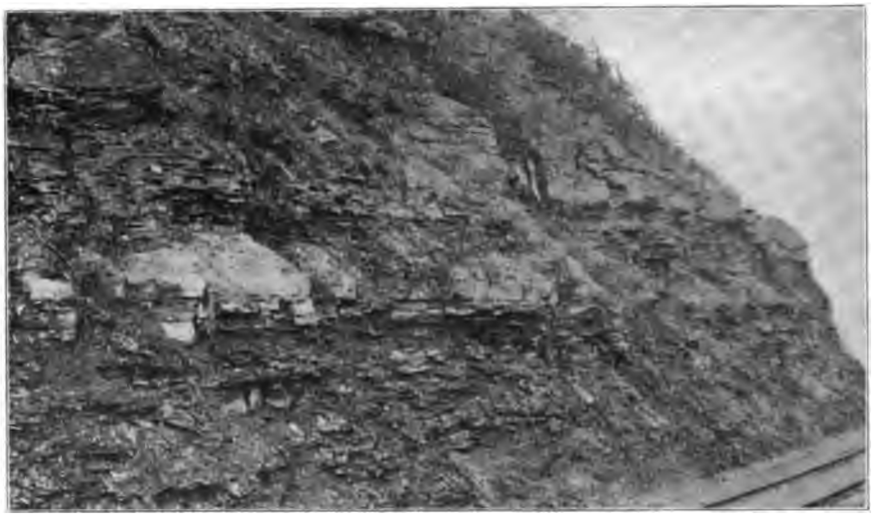
[1] Geol. Surv. Ohio, Fourth Series, Bull. 9, pp. 252-3.

[2] Geol. Surv. Ohio, Report of Progress for 1870, p. 181.

CONEMAUGH FORMATION

The general character of the rocks making up the Conemaugh formation is in marked contrast to that of the rocks composing the Allegheny formation below. During Conemaugh time, the conditions were not so favorable for the deposition of great coal beds as they were during the preceding age. Although many coal beds were laid down they are, with few exceptions, wanting in volume, shaly in character, and local in extent. On this account, this division of rocks was formerly called the Lower Barren Coal Measures. There is a great difference also in the amounts of carbonate minerals found in the two formations. The Allegheny formation contains one regularly bedded limestone and a few thin layers of shales, containing appreciable amounts of calcium, magnesium, and ferrous carbonates, which occur in fine powders or in concretionary masses of various sizes. The Conemaugh formation contains not only several well defined limestone beds, but also thick deposits of shales highly charged with these common carbonates. These minerals occur in the form of impalpable powders, and in the form of nodules, varying in size from fine seed to 1 foot, or even more, in diameter. Further, the Conemaugh shales are readily distinguished from those in the coal formations below by the increased coloration. In the former, the beds with red, brown, yellow, and green tints predominate over those with the less conspicuous gray colors, while in the latter, highly colored beds are seldom present. In a less degree this coloration of the shales is also apparent in some localities in the upper part of the Allegheny formation. The prime coloring agent is the oxide of iron, although its power is often modified, also by other pigments such as carbon, manganese oxides, and dark granitic minerals. The intensity of the color in the shales with red, brown, and yellow tints, depends primarily on both the state of hydration of the ferric oxide and on the state of division of the pigment. In the shales with green and blue shades, the principal coloring agent is ferrous compounds. The shales in the Conemaugh formation are also more clay-like in character than those in the underlying coal formations. In a general way the lithological characters of the rocks in the two divisions are notably different.

A —Typical Conemaugh topography in eastern Gallia County.



B.—Brush Creek limestones and shales exposed in the cut of the Hocking Valley Railway south of Vinton, Gallia County. The upper limestone bed is near the top of the picture and is marked by a small white paper. The lower bed, which is 20 feet below the upper one, is near the middle of the picture and is similarly marked.

Soil Features

The soils resulting from the decay and weathering of the Conemaugh rocks contain components valuable for the growth of plant life. The powdery and concretionary limestone, disseminated especially throughout the shales, continually supplies the residual soils with a sufficient amount of lime to produce luxuriant growth of plants, and especially such plants as blue grass and clover. These shales also contain phosphoric acid in appreciable amounts; further, they contain available potash in amounts adequate for the healthy growth of plant life. The fourth component necessary for plants is nitrogen, which is usually low in most of these soils. However, since these soils contain the other required substances necessary for the growth of legumes which are the great nitrogen producing class, this element may be supplied to the soils at a low cost. On the red shale soils in particular, are found tough sods of blue grass, highly valuable for grazing. The clovers also grow here luxuriantly, while the common grasses do very well. The value of these soils for fruit raising is attested by the many hundreds of acres of fine orchards found in the region. The trees are quite thrifty, long-lived, and heavy producers. The trees are also very free from the ravages of disease. Fruit raised on these soils is highly colored, hence it is attractive in appearance. In quality it is of the highest grade. These soils are far better suited for grazing and fruit lands than for general farming.

Stratigraphy

In western Gallia County, the Ames limestone, which is about midway in the Conemaugh formation, is found near the summits of a few of the highest hills. The Cambridge and Brush Creek limestones, however, are present in much of the area. The few coals found are not persistent beds, and they seldom have sufficient volume for mining. Since the economic values of the beds in the lower half of the formation are relatively small, only a few of the most important ones will be considered in this report, and these will be treated in a general way. For a more complete discussion of the formation the reader is referred to the work of D. D. Condit, on the Conemaugh Formation of Ohio.[1]

The members which have most importance, either economically or stratigraphically, are Mahoning sandstone, Mahoning coal, Mason coal, Brush Creek limestones, Wilgus coal, Cambridge limestone, and Ames limestone. These members of the Conemaugh formation will be taken up in ascending order, beginning with the oldest.

MAHONING SANDSTONE

The Mahoning sandstone, the basal member of this division of rocks, lies directly above the Upper Freeport coal of the Allegheny formation. It thus forms the roof of this important coal bed. The Mahoning sandstone, however, is very unsteady; in fact it is more often absent than present. Its position is shown by the following section taken at the mine of Emmett Oiler, in Section 18, Huntington Township:

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[1] Geol. Surv. of Ohio, Fourth Series, Bull. 17.

		Ft.	In.
Sandstone, *Mahoning*		21	--
Clay, dark		--	4
Coal, bony	*Upper Freeport*	1	2
Coal, good		3	6

The Mahoning sandstone is coarse-grained, light colored, and massively bedded. This rock is more weather resistant than the average coal formation sandstone, hence it is often employed locally for foundation work and for other minor purposes. The usual thickness of the bed, when well defined, is from 20 to 30 feet.

MAHONING COAL

The Mahoning coal lies close to the Mahoning sandstone, when this member is present, while the interval to the underlying Upper Freeport coal is found to be from 35 to 45 feet. The position of the bed and its relation to other members are shown in the following section taken near Nebo Church, in Section 17, Perry Township:

	Ft.	In.
Coal blossom, *Mahoning*	1	--
Clay shale and covered	9	--
Shale, gray	2	--
Shale, red	2	--
Covered	3	--
Shale, gray, with parts covered	9	--
Clay, mottled, with small limestone nodules	2	--
Clay, mottled	5	--
Covered	4	--
Horizon of *Upper Freeport* coal.		

The Mahoning coal is very unsteady and seldom thickens to more than 1 foot 6 inches. It is mined along the outcrop by stripping at a few places. The value of the bed in Gallia County is small.

MASON COAL

The position of the Mason coal is best located by its proximity to the Brush Creek limestone above, for the coal bed is found not far below this member. In western Gallia County it lies from 50 to 70 feet below the Cambridge limestone, which is more persistent than the Brush Creek beds. Its position with reference to other members is shown in the section taken near Nebo Church, and given under Mahoning coal. Like the Mahoning coal this bed is also mined by stripping at a few localities along its outcrop. The coal is of good quality, but the deposit is too thin to be followed under cover; hence the bed is of more value for its stratigraphic features than for its economic worth.

BRUSH CREEK HORIZON

On the Brush Creek horizon there are two limestone beds separated by shale, the average thickness of which, in western Gallia County, is about 24 feet. The upper stratum of limestone is far more constant than the lower one, but both are wanting in many localities. They are replaced by massive sandstones, which often extend from near the base of the Cambridge limestone down to the horizon of the Mason coal. The upper bed of the Brush Creek limestone in this area is usually found about 27 feet below the overlying Cambridge limestone. This interval, however, varies from 12 to 40 feet. The lithological character of these limestones varies greatly from place to place. The composition changes from a quite pure limestone through ferruginous, siliceous limestone to a flinty material, containing but little calcium and magnesium carbonates. The upper layer when only about 1 foot in thickness is usually rather pure, but when it thickens to several feet it is shaly and flinty in character. The bed shows many local thickenings, especially in its extension southward. In local areas in Lawrence County, it is a heavy flinty deposit, often measuring from 10 to 15 feet in thickness. The shales in the interval between the two limestone beds often assume a calcareous siliceous phase. The lower limestone bed usually has a thickness of about 1 foot, although in a few localities it expands to 2 or 3 feet. The composition of this bed resembles very much that of the upper one. A few sections are given in order to show the character of the deposits, and to show their relation to other members. A composite section taken along the road in Section 33, Morgan Township, is given below:

		Ft.	In.
Limestone, *Cambridge*		2	3
Clay shale, mottled		9	3
Sandstone, nodular, ferruginous		1	--
Shale, sandy, gray		17	--
Limestone, fossiliferous	*Brush Creek*	1	10
Clay shale, red		3	--
Shale, gray, sandy		11	--
Limestone, very fossiliferous		1	6
Shale, gray, sandy		18	6
Sandstone, shaly		15	--
Sandstone, massive		12	--
Coal, *Mahoning*		--	10

The upper limestone bed of the Brush Creek member is quite constant in Morgan Township, but the lower bed is rather unsteady. In Huntington Township, these limestones are found in the area east of Raccoon Creek, but they are absent in the territory west of this stream. However, a few loose blocks of limestone from these beds were observed on the summit of the high knob, in the northwestern part of Section 4. They were not found in that part of Raccoon Township north of Indian Creek and west of Raccoon Creek, although many of the ridges and knobs extend well above this horizon. Along the main ridge south of Indian Creek they are absent also, yet the Cambridge limestone is regularly present. The upper stratum of limestone is present, however, in sections 34 and 35. In this township east of Raccoon Creek, the upper layer of the Brush Creek member is quite steady.

In western Springfield Township the upper bed is commonly present, but the lower bed is seldom found. The Brush Creek member, in most of Perry Township, is represented by the upper bed of limestone, and in restricted areas it has both beds developed. The following section taken near Salome Church, in Section 23, shows the general character of the deposit:

		Ft.	In.
Shales, calcareous, with nodules of limestone, fossiliferous	*Brush Creek*	4	--
Limestone, flinty, fossiliferous		4	6
Shales, calcareous		13	--
Limestone, fossiliferous		2	--

The flinty character of the upper bed shown in the above section is quite typical of the character of this stratum in Lawrence County. This member is found near the summits of the main ridges, but in local areas only in southeastern Greenfield Township. As a general thing only the upper stratum of limestone is present. Measurements obtained along the roadside in the northern part of Section 24 follow:

	Ft.	In.
Limestone, *Cambridge*	1	--
Shales and covered	13	--
Limestone, fossiliferous, upper layer of *Brush Creek*	2	--

Only the upper limestone bed of the Brush Creek member was observed in western Walnut Township, although the lower bed may be present in limited areas.

Economic Features

The chief value of the Brush Creek limestone is for road building. The beds are widely distributed; hence they are often at the locality where road material is needed. The quantity of the loose or uncovered stone along the outcrop of the beds is usually sufficient to meet the requirements for this purpose, while if more is demanded the supply may be readily obtained by only shallow stripping. Both the high calcium and high siliceous stones are quite tough and wear well; further the shaly material has a high cementing value. Along the outcrop of the Brush Creek member good roads may be built at a relatively low cost.

WILGUS COAL

The position of the Wilgus coal is directly below the Cambridge limestone, which is a well recognized bed in the Conemaugh formation. The Wilgus coal is very unsteady and poorly developed in Gallia County, although in the vicinity of the villages of Arabia and Wilgus, in Lawrence County, the bed has good volume, and is mined by drifting for local use. This coal, however, has been mined in a small way by stripping at a few places in western Morgan Township, where the maximum thickness of the deposit is about 1 foot 8 inches. In most of this township the usual thickness observed is less than 1 foot, often only a smut streak. Although the deposit is present at other places in western Gallia County its volume is too small to justify mining.

CAMBRIDGE LIMESTONE

The Cambridge limestone is one of the well defined and generally known beds in the Conemaugh formation of southern Ohio. In Gallia County and also in Lawrence the bed is usually present on the horizon where due. There are local wants, however, where the deposit is replaced by massive sandstones. The Cambridge limestone of the Conemaugh formation resembles the Ferriferous or Vanport limestone of the Allegheny formation in texture and composition and in the types of fossils present.

The Cambridge limestone in western Gallia County lies about 27 feet above the Brush Creek member, and about 80 feet below the Ames limestone, another bed also important in stratigraphic geology. There is only one limestone stratum in the Cambridge deposit, but occasionally a thin block of iron ore, closely associated, may also be considered a part of the member. Lithologically the limestone is quite constant throughout the entire extent of the bed. In local areas the outcrop rock is somewhat siliceous, owing apparently to solution of carbonates and deposition of silica. The deposit in western Morgan Township is very steady, and is from 1 to 3 feet in thickness. The average measurement is about 2 feet. Its relation to other members is shown in the following record taken in Section 34:

	Ft.	In.
Limestone, *Ames*	2	--
Shale, gray	18	--
Clay shale, red	15	--
Shale, gray	9	--
Clay shale, red	10	--
Shale, gray, sandy	4	--
Sandstone, shaly	6	--
Covered	16	--
Limestone, *Cambridge*	2	--
Coal, *Wilgus*	1	--

From Morgan Township the Cambridge limestone extends westward to Raccoon Creek in Huntington Township. West of this stream the deposit was not found, although some of the knobs on the main ridges extend well above the horizon. The bed is quite constant in western Springfield Township, but in Raccoon Township it is wanting in the area west of Raccoon Creek and north of Indian Creek. Along the main ridge south of Indian Creek the deposit, which is very persistent, has a thickness varying from 1 to 4 feet. Large blocks of Cambridge limestone, strewn along the hillsides, are striking features of rock exposure in Perry Township. The bed often has a thickness of 4 feet and the stone has excellent quality. The high ridges in the southern part of Greenfield Township also contain good deposits of this member. The bed is from 1 to 3 feet in thickness. A record taken in Section 13 shows the interval to the upper limestone stratum of the Brush Creek member. The section follows:

	Ft.	In.
Limestone, *Cambridge*	1	--
Shales and covered	13	--
Limestone, upper layer of *Brush Creek*	2	--

The Cambridge limestone is rather steady throughout western Walnut Township, but the deposit seldom reaches more than 2 feet in thickness. Here the bed lies about 20 feet above the Brush Creek limestone, and about 120 feet above the Upper Freeport coal.

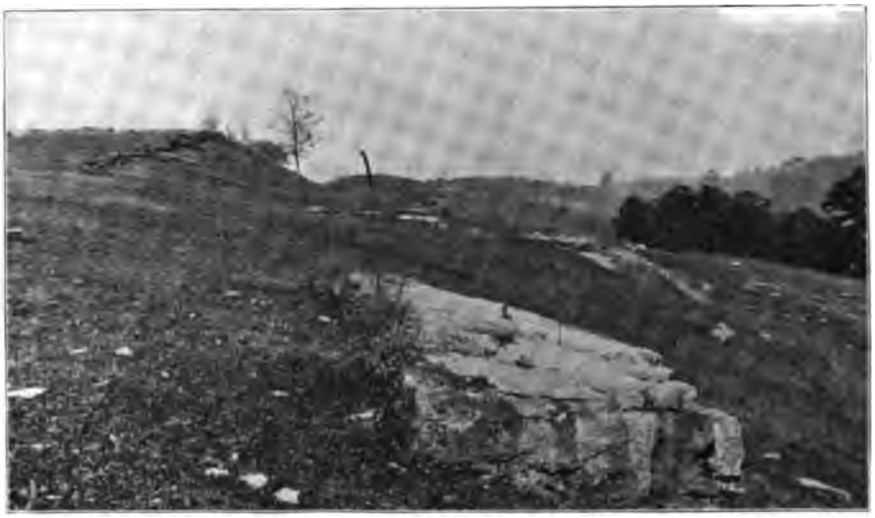
Economic Value

The Cambridge is the most important of the limestone deposits in the Conemaugh formation of western Gallia County. The bed is quite constant over a wide area; hence there are many points for attack. It is usually well exposed along its outcrop for it is more weather resistant than the associated shales. This feature is so apparent in part of the area that the bed may be traced by the eye on ridges some distance away. Large loose blocks are often found in abundance along the hillsides below its outcrop. The average thickness of the bed is about 2 feet, but in local areas this expands to 4 feet. The amount of easily available limestone that may be utilized for different purposes is large.

The stone is fine-grained and well cemented; hence it is tough but not brittle. The color of the fresh rock varies from light gray to dark gray. It contains many marine fossils which are best exposed in weathered surfaces. The stone contains only small amounts of crystalline carbonates or of siliceous matter. The chemical composition of the limestone is quite uniform throughout the county. Its qualities are shown by the following analysis by Prof. D. J. Demorest, of a sample taken on the ridge in the southern part of Raccoon Township:

Silica, SiO_2	8.40
Ferric oxide and alumina, $Fe_2O_3 + Al_2O_3$	2.00
Calcium carbonate, $CaCO_3$	87.00
Magnesium carbonate, $MgCO_3$	1.15
Phosphorus, P	0.03

The Cambridge limestone has qualities which recommend it for several purposes. Its physical properties, combined with its availability over so large an area are especially favorable for the utilization of the



A.—Outcrop of Cambridge limestone near Raccoon Falls, Gallia County.

B.—Ames limestone on Morgan Ridge east of Vinton, Gallia County.

stone in road construction. It is used some for this purpose in Gallia County and it has proved very satisfactory. The stone wears well and the dust has good cementing value. It also makes strong abutments and retaining walls. The chemical properties of the stone fit it for agricultural lime. The amounts of lime and of magnesia are in about the right proportions to meet the demands of plant life. Although the amount of phosphorus in the limestone is small, its value is worth considering, since this component is necessary for the healthy growth of plants and for the proper maturity of their seeds. Limestone from this bed is prepared in small quantity for soil purposes in Gallia County. Small portable crushers, which may be moved from place to place, are used. This stone is also of service for many minor purposes, such as walks, building foundations, cellar walls, well curbings, etc.

AMES LIMESTONE

The Ames limestone is another bed in the Conemaugh formation that is well known on account of its stratigraphic importance. It is at once recognized by the presence of certain types of marine fossils which are remarkably abundant, often constituting the greater part of the rock mass. This bed is seldom found in western Gallia County. In western Morgan Township, especially in the colored settlement, the Ames limestone is locally present. At a few places here it reaches a thickness of 2 feet, and it is conspicuous on account of the great number of fossil remains present. The bed was also observed on the high knobs in sections 30 and 31, Perry Township, where it lies about 70 feet above the Cambridge limestone. It was found again on the high ridge in Section 25, Greenfield Township, but the bed in this locality is quite thin. The Ames limestone in western Gallia County has no economic value worthy of consideration.

Fossil Horizons in Western Gallia County

Fossils are very abundant in the shales above the Tionesta coal found near old Cambria Furnace in northwestern Greenfield Township. The Ferriferous or Vanport limestone, wherever found, contains many well preserved specimens. Plant fossils are common features of the shales above the Lower Kittanning, Middle Kittanning, Lower Freeport, and Upper Freeport coals. The roof shales of the Mahoning coal, especially in western Morgan Township, contain a profusion of plant fossils which are remarkably well preserved. The Brush Creek, Cambridge, and Ames limestones are highly fossiliferous along their entire extent. Silicified wood is very common in the shales of the Conemaugh formation of western Gallia County. Many beautiful specimens may be easily obtained in the area east of Raccoon Creek.

CHAPTER VI

SEARCH FOR OIL AND GAS

The discovery of oil in the deep-seated rocks of Pennsylvania, in 1859, led to a search for this valuable product of nature in other states, and in the year 1860, the operators in Ohio were rewarded, for oil was found at Macksburg, in Washington County. Since that time the drill has been active continously in this state, and has developed many new and important fields. According to the Federal Government, the total production of oil in Ohio, in 1914, was 8,536,352 barrels with a value of $13,372,729. In the United States the utilization of natural gas for industrial purposes began in the Kanawha Valley, in 1843, when it was used for the fuel in the evaporation of salt brines.[1] In Ohio natural gas became an important factor both for domestic and industrial purposes when the great Findlay field was opened in 1884. Since then the production of this natural fuel has steadily increased so that in 1914 it was 68,270,174 M. cubic feet, with a value of $14,667,790.[2] Ohio, in 1914, ranked seventh in the production of petroleum and third in that of natural gas.

The area under discussion in this bulletin includes all of Lawrence and Jackson counties, the western half of Gallia County, and the parts of Scioto and Pike counties east of the Scioto Valley. Owing to the fact that a part of the Hamden gas field extends northward from Jackson County into Vinton, and that the Clinton sand has better development and continuity as it extends northward, wells located in the southwestern part of Vinton County will also be included in the discussion here. The search for oil in this area began about the year 1862, when shallow wells were drilled by means of the spring pole and treadle, and since then not only the shallow sands but the deep ones also have been tested by the drill at many places. On the whole the results are not especially encouraging for only traces of oil have been found. However, the production of natural gas is an item of some importance for about 50 wells out of a total of 213 drilled produce gas in commercial quantities. Sandstones usually form the reservoirs; hence they are commonly called oil or gas sands. A brief description of these sands beginning with the oldest will now be given. The section begins with the Lower Magnesian of the Ordovician and extends to the base of the Monongahela of the Pennsylvanian, an interval of more than 5,300 feet.

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[1] West Virginia Geol. Surv., Vol. Ia, p. 13.

[2] Mineral Resources of the United States, 1914, p. 751.

System.	Series.	Formation.	Average thickness in feet.	Member.	Oil or gas bearing rocks.
Pennsylvanian.		Conemaugh.	365	Connellsville sandstone. Generally present in eastern Gallia and Lawrence counties.	Mitchell sand of Washington County.
				Morgantown sandstone. Rather persistent in southern Gallia County.	Wolf Creek sand. ?
				Ames (Crinoidal) limestone. Occasionally present in eastern Gallia and Lawrence counties. Very fossiliferous.	
				Round Knob shales. Usually highly colored and quite persistent.	
				Porterville limestone and shales. Limestone thin and ferruginous, often wanting.	
				Cow Run sandstone. Usually shaly in Lawrence and Gallia counties.	Cow Run oil sand of Washington County.
				Cambridge limestone. Quite persistent in Gallia and Lawrence counties.	
				Buffalo sandstone. Not well represented in Gallia and Lawrence counties.	
				Brush Creek limestone and shales. Variable in character, and often replaced by sandstones.	
				Mason coal. Thin but usually present.	
				Mahoning sandstone. Usually thin and shaly.	

System.	Series.	Formation.	Average thickness in feet.	Member.	Oil or gas bearing rocks.
Pennsylvanian.		Allegheny.	190	Upper Freeport coal. Patchy in central Lawrence and Gallia counties.	
				Freeport sandstone. Usually thin or shaly in Lawrence, Gallia, and Jackson counties.	**Dunkard or 300-foot sand of Washington County.**
				Middle Kittanning coal. Quite persistent, but generally thin in Lawrence, Gallia, and Jackson counties.	
				Lower Kittanning coal and clay. Coal often replaced by massive sandstones.	
				Ferriferous or Vanport limestone. Usually present in Lawrence, Gallia, and Jackson counties.	
				Clarion coal. Persistent in northern Lawrence, western Gallia, and eastern Jackson counties.	
				Clarion sandstone. Very persistent throughout the area.	**Macksburg or 500-foot sand of Washington County.**
				Brookville coal. Seldom present. Usually replaced by sandstones.	
		Pottsville.	435	Tionesta sandstone. When present, usually coalesces with the overlying Clarion.	

System.	Series.	Formation.	Average thickness in feet.	Member.	Oil or gas bearing rocks.
Pennsylvanian.		Pottsville.	435	Tionesta coal. Only locally developed in eastern Jackson and Scioto, and in western Lawrence counties.	
				Upper Mercer limestone and ore. Limestone seldom present, but ore quite steady in western Lawrence, and in eastern Jackson and Scioto counties.	
				Sandstone in interval between the Upper Mercer coal and limestone. Usually persistent.	Probable position of the Second Cow Run or 800-foot sandstone of Washington County.
				Upper Mercer coal. Very steady but thin in western Lawrence, and in eastern Scioto and Jackson counties.	
				Lower Mercer limestone. Seldom developed except in northern Jackson County.	
				Lower Mercer coal. Only locally present in western Lawrence, and in eastern Scioto and Jackson counties.	
				Upper Connoquenessing sandstone. Usually present, but often broken by shales.	Usually contains salt brines, but is also the source of oil and gas. Known as Upper Salt sand.

System.	Series.	Formation.	Average thickness in feet.	Member.	Oil or gas bearing rocks.
Pennsylvanian.		Pottsville.	435	Quakertown coal. Well developed only in northern Jackson County.	
				Lower Connoquenessing sandstone. Rather persistent, but often shaly.	Known as Middle Salt sand. Nagle sand of the Willowwood field, Lawrence County.
				Sciotoville clay. Outcrops in eastern Scioto and Pike, and in western Jackson counties.	
				Sharon coal. Best developed in eastern Pike, and in western Jackson counties.	
				Sharon conglomerate. Massively developed in western Jackson, eastern Pike, and northern Scioto counties. Generally pebbly and thickness variable.	Maxton sand. Often called Lower Salt sand. Source of small quantity of oil in the Willowwood field, Lawrence County.
Mississippian.		Maxville.	0–140	Maxville limestone. Limestone interbedded with thin shales. Usually present in the wells drilled in eastern Lawrence and southern Gallia counties.	Also called Mountain and Greenbriar limestone. "Big Lime" of the drillers. Good bench mark. Probably productive in Caball County, West Virginia.

System.	Series.	Formation.	Average thickness in feet.	Member.	Oil or gas bearing rocks.
Mississippian.	Waverlyan.	Logan.	280	Vinton sandstone. Outcrops in eastern Pike and Scioto counties.	Same stratigraphic position as the Keener sand of the Sisterville field, West Virginia.
				Allensville conglomerate and shales. Seldom well defined.	
				Byer member. Sandstones with sandy shales. Outcrops in eastern Pike and Scioto counties.	Position of the Big Injun sand. Generally produces flows of salt water. Squaw sand probably at the base.
		Cuyahoga.	305	Portsmouth member. Shales with sandstones interbedded. Found above drainage along the Ohio River near Portsmouth, and along the Scioto in Pike and and Scioto counties.	
				Buena Vista member. Alternating layers of shale and sandstone. Exposed along Scioto Valley in Scioto and Pike counties.	
				Henley member. Shales with occasional thin sandstone layers.	Hamden gas sand in upper part of member. Gas occurs in several layers. The small flows of gas in the Willard wells in Lawrence County also on this horizon.

System.	Series.	Formation.	Average thickness in feet.	Member.	Oil or gas bearing rocks.
Mississippian.	Waverlyan.	Sunbury.	20	Black or coffee brown shales. Very persistent. Outcrop along the Scioto River in northern Scioto, and in Pike counties.	
		Berea.	35	Alternating layers of sandstone and shale. Very persistent but variable in thickness. Outcrop along the Scioto River in Pike and Scioto counties.	One of the important oil and gas bearing sands in Ohio.
		Bedford.	50	Shales with widely spaced, thin bedded sandstones. Part often colored with iron oxide pigments.	
Devonian.	Chautauquan and Senecan.	Ohio.	700	Shales varying from gray to black with occasional thin sandstone layers. Outcrop along Scioto River in Pike County.	Gas sand at Ironton is in the body of the Ohio shale. The position of this sand is about 270 feet above the Delaware limestone and 500 feet below the Berea sandstone.
	Erian.	Olentangy.	25	Gray shales with some thin bedded siliceous limestones.	
		Delaware.	40	Siliceous limestones. Often a few feet of brown shale at the base.	
	Ulsterian.	Columbus.	110	Light colored massive limestones. Easy to drill.	

System.	Series.	Formation.	Average thickness in feet.	Member.	Oil or gas bearing rocks.
Silurian.	Cayugan.	Monroe	290	Greenfield dolomite. Usually crystalline, soft, and light colored.	
				Hillsboro sandstone. Not persistent, variable in thickness.	Probable source of salt water and some small flows of oil and gas.
	Niagaran.	Cedarville.	50	Massive dolomites. Crystalline, usually light yellow in color.	
		Springfield.	45	Massive dolomites.	
		West Union.	50	Limestone, siliceous.	
		Osgood.	170	Shales with Dayton limestone interbedded. Formerly called Niagara shales.	
	Oswegan.	Brassfield.	20	Crystalline limestone.	
		Medina.	140	Shales and sandstones. A sandstone known to the drillers as "Clinton" sand.	The sandstone in the Medina formation is one of the most productive oil and gas bearing sands in Ohio.
Ordovician.	Cincinnatian.	Richmond.	170	Alternating beds of limestone and shale.	
		Maysville.	300	Alternating beds of limestone and shale.	
		Eden.	180	Shales, bluish and grayish.	
		Utica.	50	Shales varying in color from black to brown.	

System.	Series.	Formation.	Average thickness in feet.	Member.	Oil or gas bearing rocks.
Ordovician.	Mohawkian.	Trenton.	125	Alternating beds of limestone and shale. Limestones usually crystalline.	The most important oil-bearing rock in western Ohio.
		Lowville and Stones River.	600	Alternating beds of limestone and shale.	
		St. Peters.	175	White saccharoidal sandstone. Often shales interstratified.	An important source of oil and gas in Illinois.
	Canadian.	Lower Magnesian.	320	Dolomitic limestones with thin layers of sandstone and shale.	

Foot Note.—In the above generalized section of the rock strata in southern Ohio use was made of the works of the Ohio, Kentucky, and West Virginia Geological Surveys, of the Stratigraphy of a Deep Well at Waverly, Ohio, by R. S. Bassler, American Journal of Science, Vol XXXI, January, 1911, and of notes kindly furnished by Professor Charles S. Prosser of the Ohio State University.

The broken line indicates that there is a question whether the line of division is at the correct position.

General Consideration

The lithological character of the oil and gas producing rocks varies greatly, but the most essential feature is porosity. In this respect sandstones and crystalline limestones usually meet the requirement, and they are the most common reservoirs in which these valuable hydrocarbon compounds are stored. The character of the overlying strata is important as these must be sufficiently impervious to prevent the escape of the slowly distilled oil and gas. The geological structure must also be such that the oil and gas are not allowed to escape to the surface. The main forces active in circulation are rock pressure, capillarity, and gravity, but other factors, as viscosity, temperature, diffusion, and solubility must also be taken into consideration. A brief description of the best known sands in southern Ohio is given in the next few pages in order to define the main characteristics of these oil and gas bearing rocks. The sands will be considered in order, beginning with the oldest.

St. Peters Sand.—A sand which has been defined as the St. Peters[1] was pierced by the drill in the well located just south of Waverly, in Pike County, and it is the lowest oil or gas bearing rock reached in the area treated in this bulletin. The drill record shows it to be made up of sandstones with some shales interstratified the total thickness of which is 175 feet. It lies below the great beds of Mohawkian limestones and above those of the Canadian. Only a showing of oil and gas was found.

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[1] Geol. Surv. Ohio, Bull. 12, pp. 46-9.

Trenton Limestone.—The most important oil bearing rock in the geological column of Ohio yet discovered is the Trenton limestone. In this formation the oil is found in layers, which in the productive fields are crystalline and magnesian in character. At Waverly the drill descended through this formation, and in one well near Ironton it penetrated the upper layers. No oil was found in this rock.

"Clinton" Sand.—The "Clinton" sand of the Medina formation, like the St. Peters, lies between two great deposits of limestone, the Brassfield above, and the Cincinnatian below. The well records obtained in southern Ohio show that the "Clinton" sand lies about 200 feet below the base of the Brassfield limestone. The large producing gas wells in northern Jackson and western Vinton counties are in the "Clinton" sand. So far this sand in southern Ohio has not produced oil in paying quantities.

Ironton Gas Sand.—Near Ironton, in Lawrence County, there is found a sand in the body of the Ohio shales which produces gas in paying quantities, and which has not been correlated with any well recognized oil or gas bearing bed. For convenience, and not for stratigraphic reasons, this sand in this report will be called Ironton Gas sand. The record furnished by the Ironton Portland Cement Company shows this gas producing sand to be 578 feet below the top of the Berea sand and 272 feet above the Delaware limestone. In this locality it produces gas in commercial quantities.

Berea Sand.—The Berea is the most constant and best defined sand in the area under discussion, and is recorded in every well in which the drill descended to or below this horizon. The sand is variable in thickness, expanding erratically from 5 feet, or even less, to as much as 80 feet, and is made up of alternating layers of sandstone and shale. The sandstones are fine-grained and somewhat argillaceous in character. The Berea sand is above drainage along the Scioto River in Pike and in northern Scioto counties, but, owing to the dip of the strata to the east and south, it is about 870 feet below the surface near Hamden, Vinton County; 1,330 feet near Adamsville, Gallia County; 1,200 feet near Coalgrove, Lawrence County; 1,730 feet at Central City, West Virginia, and 1,475 feet near Gallipolis in Gallia County. In the area under discussion, although the Berea sand is present everywhere and has good covering, it has produced neither oil nor gas in paying quantities.

Hamden Sand.—In southern Vinton and in northern Jackson counties there is a small gas field in a sand that lies above the Berea.

Owing to the geographical location of the field, which is near the village of Hamden, this gas-bearing rock is here called Hamden sand. On an average the Hamden sand lies about 100 feet above the Berea sand. In the Hamden field there are about 40 producing wells in this sand. A small flow of gas was struck by the drill in the Moriah well, Section 21, Madison Township, Jackson County, in a sand 5 feet in thickness and 147 feet above the top of the Berea sand. This bed is evidently correlative with the Hamden. In the three wells drilled by E. B. Willard near Bartles, in Lawrence County, small flows of gas were found in a sand, the average position of which is 174 feet above the Berea. Here the sand is broken and varies from 5 to 30 feet in thickness. This gas-bearing sand is in the Cuyahoga formation, and appears to be on the same general horizon as the Hamden sand.

Squaw Sand.—The Squaw sand of southeastern Ohio and northern West Virginia is not well defined in the area under discussion in this bulletin. Its position appears to be close to the base of the Logan formation, or possibly in the upper part of the Cuyahoga. In a few wells, a sand with water that may correlate with the Squaw is recorded. It appears to be only locally developed, or, if present, in most places to be merged with the overlying Big Injun. In this area no sand on this horizon has produced oil or gas in paying quantities.

Big Injun Sand.—The Big Injun sand, which in this area is probably the equivalent of the Byer member of the Logan formation, is generally present, but is productive only of salt water flows. The Big Injun is an argillaceous sandstone in which more or less siliceous shales are interstratified, and on the average, it, with the overlying Keener sand, is about 150 feet in thickness. In this area it has yielded neither oil nor gas in commercial quantities. It outcrops along the Ohio River from Franklin Furnace to Portsmouth, and along the Scioto from Portsmouth to Chillicothe.

Keener Sand.—The next oil bearing sand which is known to drillers in southeastern Ohio is the Keener, the position of which is at the top of the Logan formation. It may be correlative with the Vinton sandstone of southern Ohio, or it may be another bed occupying this position. In the area under discussion this sand is not sharply defined, but a bed producing salt water is recorded in a number of wells, and is about 40 feet below the Maxville limestone, or, when this is absent, about the same distance below the base of the Pottsville formation. It is non-productive in southern Ohio.

Maxton Sand.—The evidence obtained from drill records in southern Ohio tends to show that the Maxton sand is correlative with the Sharon conglomerate, for it lies just above the Maxville limestone, or at the base of the Pottsville formation. The Sharon conglomerate outcrops in western Jackson, eastern Pike, western Vinton, and eastern Scioto counties. It is most massively developed in the northern part of this area, where the member often exceeds 100 feet in thickness and is characteristically pebbly. The well records in the southern part give an average measurement of about 40 feet with a maximum of 70, and a minimum of 10 feet. In this locality it is a sandstone containing but few pebbles. This sand is often called the Lower Salt sand, on account of the frequency with which it produces flows of brines. The Maxton is the lower oil bearing sand, in the Willowwood field, in Lawrence County, but from records collected elsewhere in Lawrence County and in Gallia, it is productive only of flows of salt water.

Middle Salt or Nagle Sand.—In the Willowwood field, in Lawrence County, there is a sand averaging about 22 feet in thickness, and lying about 43 feet above the Maxton, that has given a showing of oil. This sand correlates with the sandstone that is generally present above the Sciotoville clay, in Scioto and Jackson counties, and is probably the equivalent of the Lower Connoquenessing sandstone of Pennsylvania. Oil drillers often call it the Middle Salt sand. When characteristically developed, it is a light colored, medium grained sandstone with but little argillaceous bonding matter. However, in some localities it contains interbedded layers of shale or gradates into thin bedded shaly sandstones interstratified with shales.

Upper Salt Sand.—The Upper Salt sand which appears to be correlative with the Upper Connoquenessing of Pennsylvania, and which lies between the Quakertown and Lower Mercer coals, has produced small flows of gas in a few wells, but it usually yields only salt water for the money and labor expended. The bed in places is many feet in thickness, and, in fact, it often appears to be made up of two or more strata separated by thin layers of shales. It is a sandstone of the usual coal formation type. In this area the Upper Salt sand has produced neither oil nor gas in commercial quantities.

Second Cow Run or 800-foot Sand.—The position of the Second Cow Run or 800-foot sand appears to be between the Upper Mercer coal and the Upper Mercer limestone, although it may be just above the latter member. As the upper part of the Pottsville formation contains many beds of massive sandstone, oil or gas may be found at almost any horizon. The sands on this general horizon have produced only small flows of gas in a few wells in southern Ohio. However, flows of salt brines are commonly found when these beds are penetrated by the drill.

Macksburg or 500-foot Sand.—The position of the Macksburg or 500-foot sand has not been definitely established, but it appears to be on the horizon of the Clarion sandstone; possibly it may be as low as the Tionesta. Moreover, in many localities these two sandstone members are merged into one thick bed, while at other places either one or the other may be replaced by shales. The outcrops of the Clarion and Tionesta sandstones extend northward from the Ohio River near

Ironton into Vinton County near Radcliff. Thus far the Macksburg sand in this area has been unproductive.

Dunkard or 300-foot Sand.—The next higher sand which has yielded oil in southeastern Ohio is the Dunkard or 300-foot sand. It has been correlated with the Freeport sandstone, which is generally thin or shaly along its outcrop in eastern Lawrence and western Gallia counties. Owing to the shallow covering on this bed, but little may be expected of this sand in Lawrence and Gallia counties.

Cow Run Sand.—The position of the Cow Run sand, as given by Bownocker, is just above the Cambridge limestone. This sand is above drainage in all the area under discussion in this bulletin, except in small areas in eastern Lawrence and Gallia counties.

SOUTHERN VINTON COUNTY

Owing to the fact that the "Clinton" and Hamden sands, both of which have yielded good volumes of gas, extend southward from the southwestern part of Vinton County into Jackson, the wells drilled in most of the Allensville and Hamden fields will be included in this bulletin. The records of the wells in these fields give a starting point for the stratigraphic extension of the producing beds southward; hence they are of value in the interpretation of well logs in the non-productive territory from the northern part of Jackson County to the Ohio River. See Map X, Part 1.

"CLINTON" SAND

The "Clinton" sand has been penetrated by the drill in a number of the wells located in Vinton County, and in a few places it has produced large volumes of gas, but as yet no oil. The sand lacks continuity and is variable in thickness and in character. Although not often productive, it seldom contains salt brines. The position of the bed is about 180 feet below the base of the thick Silurian limestone, and about 1,675 feet below the top of the Berea sandstone. This sand is interbedded in shale, part of which is often highly colored with iron oxide pigments.

In the following record furnished by C. H. Garard, of the Ohio Fuel Supply Company, Wellston, Ohio, the "Clinton", Berea, and Hamden sands are shown in about their normal positions. The well was drilled on the land of S. C. Walden and D. Bone, in the central part of Section 28, Richland Township.

	Thickness in feet.	To bottom of formation.
Conductor	68	68
Shales	207	275
Sandstone, *Big Injun*, with water at 400 feet	150	425
Shales	275	700
Sandstone, gray, (*Hamden*), with gas and water	35	735
Shales	117	852

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[1] Geol. Surv. Ohio, Bull. 12, p. 43.

Y, (*Hamden*), with gas and water	35	735
------------------------------	117	852

		Thickness in feet.	To bottom of formation.
Sandstone, gray, (*Berea*)		35	887
Shales, (*Bedford* and *Ohio*)		813	1,700
Limestones with water at 2,130 feet. (Includes limestones from top of *Devonian* to base of *Silurian*)		640	2,340
Shales		163	2,503
Shale, hard and shelly		6	2,509
Rock, red	*Medina*	12	2,521
Sandstone, "*Clinton*,"		15	2,536
Shale, gray		30	2,566
Shale, light gray		15	2,581
Shale, red		10	2,591
Shale, gray		15	2,606

The following casing was used in the well:

10 inch	68 feet.
8¼ inch	930 feet.
6 inch	2,360 feet.

In the same section a large producing "Clinton" gas well was drilled on the land of Granville S. Jackman, and another on that of the heirs of William Poland. On the ridge in the eastern part of this section, on the property of A. F. Nichols, the "Clinton" sand was penetrated by the drill, but without results. Another attempt was also made to locate productive territory in the eastern part of Section 29 where a dry "Clinton" well was drilled on the land of William Nichols. This well is reported to be about 2,600 feet in depth. On Kelley Branch, in Section 21, on the property of John A. Bethel, an unproductive test was made of the "Clinton" sand. The drill started just above the top of the Logan formation and descended to a depth of 2,580 feet.

At this place the "Clinton" sand was dry, but the Hamden sand at 560 feet gave a showing of gas. About one mile west of Allensville on the land of Ezekiel Ratcliff, in the southwestern part of Section 5, Richland Township, a test of the "Clinton" sand was made for gas, but it gave no reward for the labor and money invested. Below the base of the Silurian limestones two sands, both of which were dry, were found, one at a depth of 2,080 feet and another at 2,130 feet. A showing of oil was obtained near the top of the Delaware limestone at a depth of 1,265 feet. A test well was also drilled about one mile east of Allensville on Riley Run, on the land of H. C. Wyatt, in the northeastern part of Section 9, Richland Township. Mr. Wyatt states that the "Clinton" sand was reached at 2,200 feet, and that the drill stopped at 2,250 feet.

"The 'Clinton' was reported about 11 feet thick, with a little gas in the top and near the bottom."[1] At present there is a small seepage of gas and a flow of brine.

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[1] Geol. Surv. Ohio, Bull. 12, p. 43.

In 1915 a 'Clinton" well, which is reported to have produced, when first drilled in, 8,000,000 cubic feet of gas per day, was drilled near Olive Church, about one mile northeast of Allensville. No record was obtained. On the property of I. N. Bay, in Section 7, Clinton Township, a test of the deep sands was made, but the results were unfavorable as neither oil nor gas was secured. This well is located just north of the road and east of Little Raccoon Creek. The top of the Clinton sand is reported to have been reached at 2,576 feet and the bottom at 2,587 feet. It is also stated that the drill stopped in the Medina red shales at a depth of 2,666 feet.

BEREA SAND

The Berea sand has excellent continuity in the southwestern part of Vinton County, but so far it has produced neither oil nor gas in commercial quantities. In a few places it has yielded small flows of gas, while at other places it produces only brines. This sand is quite variable in thickness from place to place and is made up of alternating beds of sandstone and shale. But few wells in which the intention of the operator was to test only the Berea sand have been drilled in this area. These are listed in the next few lines.

In the northwestern part of Section 3, Richland Township, on the property of the William Poland heirs, a Berea well was drilled. The sand was located at 702 feet, but drilling was continued to 716 feet where a flow of brine was encountered. On the Elizabeth Tripp property, in Section 25, the drill struck the Hamden sand at a depth of 614 feet and the Berea at 734 feet. Both sands were dry. At the village of Hamden a Berea well was drilled on the land of Alexander Porter, in Section 30, Clinton Township. The sand was found at a depth of 730 feet but gave no showing of either oil or gas. At Lake Alma, in Section 29, of the same township, C. K. Davis drilled a test well that gave a small flow of gas. The Hamden sand, here productive, was found at a depth of 656 feet, and the Berea with only a showing of gas at 814 feet. The head of this well is about 40 feet below the Lower Mercer limestone.

A Berea well was drilled in the fall of 1909 on the land of the Puritan Brick Company near its plant in Section 21, Clinton Township. The following log of the well was kindly furnished the Survey by the company:

	Thickness in feet.	To bottom of formation.
Surface	6	6
Shale	12	18
Sandstone	4	22
Shale with thin bed of *Quakertown* coal	58	80
Sandstone	50	130
Shale	60	190
Sandstone	50	240

	Thickness in feet.	To bottom of formation.
Shale	30	270
Sandstone with water	40	310
Shale	15	325
Sandstone with water	20	345
Shale	30	375
Sandstone	30	405
Shale	50	455
Sandstone	285	740
Sandstone with salt water	5	745
Shale	20	765
Sandstone with gas (*Hamden*)	25	790
Shale	80	870
Sandstone, *Berea*	6	876

The test was unproductive as it gave only a showing of gas. The sandstones with water at 270 and 325 feet are in the Big Injun, while that at 190 feet appears to be the Sharon conglomerate or its equivalent.

East of Raccoon Creek, in the southeastern part of Section 27, Wilkesville Township, on the property of the Federal Coal Company, a test was drilled to the Berea sand, which is reported by John McCormick to be about 1,300 feet below the surface. The head of this well is about 15 feet below the top of the Ferriferous limestone. Neither oil nor gas was found in commercial quantities.

HAMDEN SAND

The stratigraphic position of the Hamden sand is about 100 feet above the Berea sand, and on the average about 470 feet below the base of the Pottsville formation. A description of the wells and of their locations is given in the next few paragraphs. The Survey is indebted to C. H. Garard of the Ohio Fuel Supply Company, Wellston, Ohio, for the main facts concerning this field.

On the land of the William Poland heirs, in Section 5, Richland Township, a well was drilled to the Hamden sand, but it produced only a small flow of gas and was soon abandoned. On the same property, about one-half mile north of Richland Furnace, a test was made of this sand, but gas in paying quantities was not secured.

A producing gas well in the Hamden sand, which was reached at a depth of 750 feet, was drilled on the land of J. W. Betts, in the central part of Section 3, Richland Township. In the southern part of this section, on the property of L. W. Poland, the Hamden sand, which gave a commercial flow of gas, was found at a depth of 611 feet below the surface. Another producing well was drilled to this sand on the L. W. Poland farm, in the southeastern part of Section 3. The depth recorded is 656 feet. North of this, at the head of an eastern tributary of Little Raccoon Creek, in the same section, on the land of J. W. Wortman, a well 742 feet in depth gave a good flow of gas which came from the Hamden sand.

In the southwestern part of Section 2, Richland Township, on the farm of William J. Cox, the drill found the Hamden sand, which gave a good flow of gas at a depth of 796 feet. North of this near the small stream another well was drilled on this property. Here this shallow sand was struck 709 feet below the surface and was productive. Gas was also obtained at a depth of 712 feet on the farm of Irenaus Harper, in the northern part of Section 2. Along the stream in the central part of this section, on the farm of Jane A. Wortman, production was obtained in the Hamden sand at a depth of 689 feet. Another well 698 feet in depth on this property, but in the southeastern part of Section 2, also gave a good flow of gas. In the northeastern part of this section two producing wells were drilled into the Hamden sand. One located on the farm of Stephen A. Tripp is 723 feet deep, and the other on that of Harriet Jane Roach is 796 feet.

In Section 1, Richland Township, eight wells were drilled to the Hamden sand. On the land of W. O. Tripp, in the northwestern part of the section, the drill found the productive sand at a depth of 764 feet. South of this near the road, but on the same property, a producing well was obtained at a depth of 695 feet. The third producing well on this property, 757 feet in depth, is located south of the small stream. Along the road southeast of the above, on the Stephen A. Tripp property, the Hamden sand here productive was reached at a depth of 687 feet. Another well 678 feet in depth, located on the same property, and just north of the road in the southeastern part of the section, gave a commercial flow of gas. Along this tributary of Little Raccoon Creek, in the central part of this section, a dry test was drilled on the property of E. C. Wortman. On the hill south of the stream, in the northeastern part of the section, on the farm of Euphema Henderson, a flow of gas was secured at a depth of 748 feet. North of this on the land of Etha A. Snook production was obtained at a depth of 736 feet.

On the hill in the southern part of Section 36, Richland Township, the Hamden sand was tested on the land of Dora A. and T. M. Buskirk. The well which was 742 feet in depth gave only a small flow of gas and was soon abandoned. In the central part of Section 35, on the C. W. Traphagen property, gas was obtained in paying quantities at a depth of 647 feet. In the southwestern part of this section, on the farm of F. H. Bay, the productive sand was found 764 feet below the surface. West of this on the same property, but in Section 35, a flow of gas was secured in the Hamden sand at a depth of 787 feet. South of the Darby School, on the farm of R. F. Traphagen, the shallow sand, 634 feet below the surface, gave a good flow of gas, as it did also at a depth of 699 feet in the western part of this section on land of Anna E. Johnson.

The Hamden sand, which was reached by the drill somewhere between 642 and 661 feet, was dry where tested on the property of

Timothy Cassill, in the central part of Section 26. Another unproductive test between 650 and 690 feet in depth was drilled on the farm of S. E. Murphy, in the central part of Section 27. In Section 32, Elk Township, on the farm of Paul Trimmer, a test was drilled 726 feet in depth. It is reported to be a Berea well, but when plotted appears to have reached only the Hamden sand. The head of the well is just below the position of the Lower Mercer limestone. Neither oil nor gas was secured in paying quantities.

Only a few producing wells have been secured in the Hamden sand in Clinton Township. On the farm of I. N. Bay, in the southwestern part of Section 7, gas was found in this sand at a depth of 675 feet. Along the road in the western part of Section 18, on the property of E. C. Wortman, the Hamden sand was also productive. On this property another producing well was drilled in the southwestern part of the same section. At this place the depth of the gas producing sand is 673 feet below the surface. Near the northern boundary of Section 19, on the farm of H. K. Madison, this shallow sand at a depth of 763 feet gave a good flow of gas. On the Poore Brothers' farm, just northeast of the village of Hamden, in Section 20, a test drilled to this gas-bearing sand was unproductive. A number of years ago a shallow well which may have penetrated the Hamden sand was drilled for water at the Baltimore & Ohio Southwestern depot at Hamden. It yielded a small flow of gas for many years and was instrumental in leading to a more thorough search for gas in this locality.

JACKSON COUNTY

Many wells have been drilled in Jackson County in an attempt to find oil in the deep-seated rocks, but so far the tests have been unproductive. However, gas has been secured in both deep and shallow sands in the northern part, and the fields may be extended by future work. See Map X, Part 2.

"CLINTON" SAND

The evidence obtained by the few tests made in Jackson County indicates that the "Clinton" sand is confined to isolated patches, and that in these the producing bed is variable in thickness and in character. It is interbedded in shales, and lies about 200 feet below the base of the great beds of Devonian and Silurian limestones, which are about 590 feet in thickness here. Descriptions of the "Clinton" wells follow:

The Buckeye Coal Company well No. 2, drilled by the Cheshire Oil & Gas Company in 1906, is located at the mouth of Glen Nell Hollow, Section 20, Washington Township. The record furnished the Survey is as follows:

	Thickness in feet.	To bottom of formation.
Not recorded	640	640
Sand, *Berea*	20	660
Not recorded	794	1,454

		Thickness in feet.	To bottom of formation.
Limestone	(Limestone, *Devonian* and *Silurian*)	296	1,750
(First water at 1,550)			
Shale		10	1,760
Limestone		290	2,050
Shale, chocolate		140	2,190
Shale, white		40	2,230
Shale, brown		15	2,245
Shale, white		10	2,255
Sand, "*Clinton*"		8	2,263
Shale, white	(*Medina*)	44	2,307
Shale, red		8	2,315
Total depth			2,315

The head of this well is close to the base of the Sharon conglomerate. The "Clinton" sand was productive, and the well came in with a flow of 4,000,000 cubic feet of gas per day. The volume of the gas gradually diminished, and in a few years became so small that the well was abandoned.

Along Pigeon Creek just south of the mouth of Glen Nell Hollow in Section 20, another test known as the Buckeye No. 1 well was drilled to the "Clinton" sand, but it failed to produce gas in commercial quantities. This well was drilled by the Cheshire Oil & Gas Company in the year 1906. North of the mouth of Glen Nell, on the land of R. W. Wills, this company drilled another well, the early production of this being 500,000 cubic feet of gas per day. The well was abandoned a year or two ago. The thick beds of Devonian and Silurian limestones shown by the record are 589 feet in thickness, and the producing "Clinton" sand, 4 feet in thickness, lies 191 feet beneath the limestones. The "Clinton" sand was struck at a depth of 2,266 feet, and the Berea sand at 665 feet. A flow of water was encountered at a depth of 465 feet, and three flows in the massive limestones at depths of 1,584, 1,880, and 1,925 feet, respectively. The well head is near the top of the Sharon conglomerate, and its altitude is about 680 feet. The total depth reached was 2,290 feet.

On the west bank of Pigeon Creek in the central part of Section 20, the Wills No. 2 well was completed in the year 1907. The drill started near the top of the Logan formation and penetrated the rocks to the Medina red shales, but liberated neither oil nor gas in paying quantities. The total depth of the well was 2,335 feet. The Berea sand, 3 feet in thickness, and with a small flow of gas, was found at 610 feet, and the base of the Devonian and Silurian limestones at 2,000 feet. Below this there were 335 feet of variously colored shales and sandstones with some shelly limestone. A showing of oil was obtained in the body of the great beds of limestone at a depth of 1,490 feet, while water was struck at 330 and 1,880 feet. Evidently the horizon of the "Clinton" sand was passed in this test. A "Clinton" well, the initial

ART II.

production of which is reported to be 1,250,000 cubic feet of gas per day, was recently (1916) drilled by the Ohio Fuel Supply Company on the Frank J. Pittenger property in Section 27, Coal Township. No details concerning this work were obtained.

Along Buckeye Creek three miles west of Jackson, T. N. Barnsdale in 1898, drilled a deep test on the Rachael Long farm in Section 23, Liberty Township. This well started close to the base of the Sharon conglomerate. Isaac Long reports that the drill stopped in limestone at a depth of 2,155 feet. Further, he states that it was the intention of the operators to drill deeper so that about 600 feet of casing, securely capped, were left in the well. No detailed record was obtained, but it evidently passed the horizon of the "Clinton" sand, and is here considered a dry "Clinton" well.

A deep well reported to be far below the "Clinton" sand was drilled on the Alice D. Johnson farm, in the northern part of Section 36, Scioto Township. It was drilled by a company from Jackson, Ohio. No information regarding the rock strata passed through was secured. Neither oil nor gas was found in paying quantities. Another well, which from the depth reported, 1,834 feet, should have reached the "Clinton" sand, was drilled on the Edwin S. Johnson farm, in the central part of Section 36, Scioto Township. No production was obtained.

On Hewitt Run, on the E. M. Gerken farm, Section 10, Jefferson Township, a deep well was drilled in 1905 by the Cheshire Oil & Gas Company. The tools, here starting approximately 160 feet below the top of the Ferriferous limestone, penetrated the rocks to a depth of 2,750 feet in an attempt to locate the "Clinton" sand. The record given below was furnished by C. H. Garard of the Ohio Fuel Supply Company, Wellston, Ohio:

	Thickness in feet.	To bottom of formation.
Not recorded	200	200
Coal (*Sharon*)?	3	203
Not recorded	532	735
Sand, *Berea*	45	780
Shales, (*Bedford* and *Ohio*)	740	1,520
Not recorded	255	1,775
Limestone, (*Devonian* and *Silurian*)	570	2,345
Shale	20	2,365
Red rock	100	2,465
Shells	50	2,515
Pink slate, ("*Clinton*")?	10	2,525
Red shale	155	2,680
(Pencil cave at 2,680)		
Red shale	70	2,750

Water was found in the Carboniferous rocks at depths of 200 and of 350 feet, and in the Niagaran limestones at those of 2,188 and 2,206 feet, respectively.

BEREA SAND

The Berea sand in Jackson County has excellent continuity, for it is reported in every carefully made and authentic record obtained by the Survey. The average thickness of the formation is about 20 feet, while the variation is from 3 to 45 feet. The Berea sand has given a showing of oil or gas at many places, but, so far, it has yielded neither of these products in commercial quantities. A brief description of the wells with their locations follows:

In the northern part of Section 9, Washington Township, on the land of the William Poland heirs, a well was drilled for oil in the year 1862. Gas was found in good volume, and is issuing in small quantities at present (1915).

On the farm of A. G. Ray, located about one mile west of the village of Byer, and in Section 7, Washington Township, a well, variously reported from 1,600 to 2,000 feet in depth, was drilled in search of oil or gas. This well evidently passed below the Berea sand and may have reached the "Clinton" sand, but as no accurate information was obtained it is here listed as a Berea test. It was drilled in 1898 by a company of Parkersburg men, of which Mr. Pike was manager. The Hamden sand is reported to have been found at a depth of 540 feet. The test gave neither oil nor gas in paying quantities.

On Glade Run, on the property of B. Gertrude Dyer, in the central part of Section 19, Washington Township, an attempt was made to locate productive Berea sand, but it did not meet with success. The test was made in 1909, and the record furnished by C. A. Dyer is given below:

	Thickness in feet.	To bottom of formation.
Surface	11	11
Shale and sandstone	80	91
Water at 56 feet.		
Sandstone	29	120
Sand, very hard	1	121
Sand and shale	29	150
Water at 150.		
Shale, light	50	200
Shale, light	144	344
Sand, Big Salt water	1	345
Sand	7	352
Shale	113	465
Sand	15	480
Shale	7	487
Sand	17	504
Shale	16	520
Shale gas. (Horizon of *Hamden* sand.)		
Shale	90	610
Shale, dark	9	619
Sand (*Berea*)	6	625

Gas at 620, and salt water at 625 feet.	Thickness in feet.	To bottom of formation.
Shale	20	645
Shale, red	72	717
Shale, lead colored	4½	721½

East of Pigeon Creek, in the northern part of Section 20, Washington Township, the Berea sand was found at a depth of 720 feet on the farm of Wilson Lively. A showing of gas was the only reward. The well head is near the surface of the Logan formation. A Berea well was drilled on the property of the Wellston Furnace Company north of the plant. Concerning this, Bownocker says:

> The only test reported here was made at Wellston in the summer of 1902. A depth of 800 feet was reached which was probably sufficient for the horizon of the Berea grit. The only reward was a small show of oil and gas. The well head is reported at about 85 feet above the Wellston or No. 2 coal.[1]

Near the No. 10 mine, on the land of the Superior Colliery Company in Section 13, Milton Township, a test, which is reported to have reached the Berea sand, was made, but produced neither oil nor gas in paying quantities. The drill started on the level of the Lower Kittanning coal. South of Glenroy, near the abandoned Tom Corwin mine, C. K. Davis drilled a test to the Berea sand. The well head is about 90 feet above the Quakertown or Wellston coal. The Berea sand, with only a showing of oil and gas, is reported to have been reached at a depth of approximately 800 feet.

Northwest of Jackson near Buzzard Rock, on the land of John L. Long, in Section 19, Lick Township, an unproductive test of the Berea sand was made by Jackson people. The drill, starting near the middle of the Sharon conglomerate, which in this locality is approximately 125 feet in thickness, reached the Berea sand, according to George Pugh, a resident of Jackson, at a depth of 740 feet, and stopped at 750 feet. Only a showing of oil and gas, which with salt water are still issuing, was secured. On the farm of Louis A. Brown, in the southeastern part of Section 25, Scioto Township, a test of the Berea sand was made, and a showing of oil secured. In fact, a few barrels of a dark oil were pumped, but the flow was too small to justify further operation. This well was drilled by a company from Jackson, Ohio.

Near the Hocking Valley depot, in 1886, the authorities of the town of Jackson drilled a well for oil or gas, but the latter product was the one desired, on account of its ready application for fuel. A small flow of gas was secured in the Berea sandstone, and was utilized for a number of years in heating and lighting a residence near by.

Near Moriah Church in Section 21, Madison Township, a test of the rocks to the Devonian limestones was made on land of Thomas E. Edwards, but the results were unfavorable. The drill here started on the level of the Ferriferous limestone.

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[1] Geol. Surv Ohio, Bull. 1, p. 275.

A Berea well was drilled east of Symmes Creek on land of D. W. Williams, in Section 2, Madison Township. A strong flow of gas was struck in the upper salt sand at a depth of 445 feet, but the Berea sand contained neither oil nor gas in paying quantities.

On the farm of H. H. Stevenson, in Section 25, Hamilton Township, the Berea sand, 12 feet in thickness, was reached at a depth of 611 feet. The drill started near the top of the Logan formation, and at an elevation of about 640 feet above tide. Flows of salt water were found at depths of approximately 300 and 400 feet, respectively. The Berea sand gave only a small flow of gas, which is escaping at present (1915). The Survey is indebted to S. Stevenson and D. D. Davis for these brief facts.

A shallow well, which is reported in the Berea, was drilled on Cub Run, on the land of the Jefferson Iron Company, in Section 21, Jefferson Township. At first it produced a small flow of gas but no showing of oil.

Another shallow test, also reported Berea, was drilled just east of Jefferson Furnace, in Section 14, Jefferson Township. This well was unproductive. Mr. Davis stated that the sand, 5 feet in thickness, was found at a depth of 610 feet, but it likewise furnished only a small flow of gas. In one of the higher sands a strong flow of salt brine was encountered. Here the top of the Ferriferous limestone is 130 feet above the head of the well, or the interval from the limestone to the sand is 740 feet. This is much too short to reach the Berea sand. Both this and the above well may have been drilled only to the Hamden sand.

HAMDEN SAND

In the Hamden sand, in the northeastern part of Washington Township, there is a small field which has produced a good volume of gas for several years, and is not yet exhausted. South of this, small flows of gas from this horizon are noted in a few wells; hence there is some hope that the area of production may be extended. In the well near Moriah Church, in Section 21, Madison Township, gas was found in a sand 147 feet above the Berea. Near Oak Hill and Jackson, small flows of gas are found on this horizon, while in the Willard wells near Bartles, in Lawrence County, a sand with gas lying on an average 185 feet above the Berea is well defined, and probably correlative with the Hamden sand. As previously stated, the Hamden sand in northern Jackson County, lies about 100 feet above the Berea. The main facts regarding the wells in Washington Township were kindly furnished the Survey by C. H. Garard, of the Ohio Fuel Supply Company, Wellston, Ohio. A brief account of the field follows:

Seven wells that penetrated only the Hamden sand have been drilled in Section 12, Washington Township. In the eastern part south of Johnson Run, on the land of E. C. Wortman, the Hamden sand was found at a depth of 695 feet, and it gave a good flow of gas. Near the central part of the section three producing wells were drilled, one 686 feet deep on the land of Minnie E. Walker, one 685 feet on that of Thomas Hogan, and another 702 feet on that of James W. Harbarger. On the ridge, in the northern part of this section, production was also obtained in the Hamden sand at a depth of 757 feet, on the property of Stephen M. Tripp. In the western part of the section, also on the ridge and on the farm of Minnie E. Walker, the drill released gas at a depth of 697 feet. In the southern part, on the James W. Harbarger farm and near the head of Johnson Run, production was obtained in this shallow sand at a depth of 714 feet.

South of Johnson Run, in the eastern part of Section 11, on the property of T. M. Kinsel, the Hamden sand which gave a good flow of gas was struck at a depth of 697 feet. Farther up the stream on the same property, production was obtained at a depth of 723 feet. Near the center of the section west of where the road crosses Johnson Run, 712 feet were drilled before the shallow sand, which gave a flow of gas, was reached. Just west of the road in the southern part of Section 11, on the property of Jane Cox, a flow of gas was secured 702 feet below the surface.

Just east of the Baltimore and Ohio Southwestern Railroad, in the southern part of Section 10, on the land of Robert S. Wilcox, only a small flow of gas was obtained in the Hamden sand at a depth of 726 feet, and the well was soon abandoned. A dry hole was secured on the land of J. M. Leasure, east of the railroad in the central part of this section. The producing sand was struck at a depth of 740 feet, but the flow of gas was too small to pay for piping. Only a short distance north of this, but west of the railroad, on the farm of William Walburn, production was obtained at a depth of 742 feet.

Just south of the railroad, in the northeastern corner of Section 9, on the L. W. Poland property, a test of the Hamden sand gave only a small well which was soon abandoned. Near the village of Byer, four wells, which went only to this gas bearing sand, were drilled. For information concerning these the Survey is indebted to Guy Stevenson, W. H. Conway, T. W. Hunsicker, and L. S. Peoples, residents of the village. The depth of the well, located just east of the Christian Church, is between 600 and 650 feet, which depth would reach only the Hamden sand. The work was done in 1890 or 1891, by the Southern Ohio Oil and Gas Company. Neither oil nor gas was secured in paying quantities. This company in 1892 also drilled the test located in the street near the residence of Guy Stevenson, and reported to have a depth between 600 and 650 feet. The Hamden sand at this place yielded small flows of both oil and gas, which at present (1915) are found escaping from the casing, but only in trifling quantities. Just south of the village, near the mouth of the eastern tributary of Pigeon Creek and on the land of A. J. and W. J. Doles, a well about 500 feet deep was drilled in the year 1895 or 1896, but the results were unfavorable. Another well was drilled on the east bank of Pigeon Creek, in the southern part of Section 8, on the farm of S. M. Winters. The test was put down to a depth of 590 feet, which reached the Hamden sand, but it gave neither oil nor gas in commercial quantities.

On Sand Run, in the southwestern part of Section 13, a dry well was drilled on the property of Juliet Campbell. The Hamden sand was found at a depth of 690 feet. Another test was tried north of Sand Run, in the central part of Section 14, on the farm of J. A. Funk. A small flow of gas was secured in this sand at a depth of 705 feet. In the southeastern corner of Section 15, on the property of J. H. Blamer, a well was drilled in 1901. The drill penetrated only the Hamden sand, for the depth reported is 768 feet. The test was unproductive.

Two tests, reported Berea, but evidently only Hamden, were drilled for gas by Edwin Jones. They are located just east of the station of the Detroit, Toledo & Ironton Railway at Jackson. These wells started near the horizon of the Sharon coal. Mr. Jones states that in the well in the rear of Darlings' store 4 feet of sand which produced gas, but which had water in the base, was reached at a depth of 550 feet, while in the other test at the same depth a fine flow of gas was found in the sand which also soon flooded with water, thereby ruining the well. This test was then drilled 100 feet deeper, but nothing of interest was found.

BIG INJUN SAND

In drilling for water at Milton Furnace, in Wellston, a small flow of gas, which yet escapes, was found. Concerning this well, H. L. Willard, Jr., reports, that it is between 400 and 450 feet deep. At about 300 feet a small flow of fresh water was struck, and at about 450 feet a strong flow of salt brine was obtained. The drill in this well stopped in the Big Injun sand.

EASTERN HALF OF PIKE COUNTY

The search for oil and gas in Pike County, began about 1860, and has continued in a desultory way to the present time. The early wells drilled by a spring pole penetrated only the earth below to a depth of a few hundred feet at most, but the test drilled, near Waverly, in 1908 and 1909, extended into the pre-Cambrian rocks.[1] In several other wells the drill has reached the horizon of the Clinton sand, but has failed to reveal productive fields.

"CLINTON" SAND

The "Clinton" sand is not well defined in eastern Pike County, and, so far, has produced neither oil nor gas in paying quantities. The few records obtained show that the horizon of the "Clinton" sand is about 170 feet below the base of the massive Devonian and Silurian limestone beds, which here are only about 450 feet in thickness. The Bedford and the Ohio shales are also somewhat thin, so that the interval from the Berea sand to the horizon of the "Clinton," which interval in Vinton County is about 1,640 feet, is in this locality only approximately 1,250 feet. A brief survey of the search for oil and gas in the "Clinton" sand in eastern Pike County follows:

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[1] The Stratigraphy of a Deep Well at Waverly, Ohio, by R. S. Bassler, American Journal of Science, Vol. XXXI, No. 181, Jan., 1911.

On the W. A. Wynn farm, near Riverdale, Newton Township, a deep test well was drilled. The drill, which stopped at a depth of 2,300 feet in the Mohawkian limestones, failed to release the desired products. A small flow of gas was found near the top of the Devonian limestone, at a depth of 500 feet, and another flow on the horizon of the "Clinton" sand. Below this, however, no showing of either oil or gas was secured. For these brief notes the Survey is indebted to Mr. Wynn.

East of Piketon, a "Clinton" well was drilled on the land of C. K. Patterson, in the year 1896 or 1897. The well head is near the top of the Ohio shale. The main items concerning this test were furnished the writer by Mr. Patterson. The great beds of Devonian and Silurian limestone seemed to be full of water, for although the drillers cased seven times, yet they failed to secure a dry hole until they had drilled through this formation and cased in the shales below. In these limestones there was found considerable gas, the pressure of which for many years was sufficiently strong to force the gas through the 900 feet of water that filled the hole. At a depth of about 1,025 feet, a light amber oil, which was evidently from the horizon of the "Clinton" sand, was found and was pumped for several months. Small quantities of oil and gas as well as brines are yet issuing from the well. The rocks penetrated were approximately 80 feet of glacial drift, 425 feet of different kinds of shale, 425 feet of Devonian and Silurian limestones, and 85 feet of shale, below which was found the "Clinton" oil bearing sand at a depth of 1,015 feet.

In the California Valley, south of the village of Beaver, on the farm of Watson Gilliland, in Section 10, Marion Township, a deep well was drilled in the year 1899. The log of this test on file at the office of the Survey follows:

		Thickness in feet.	To bottom of formation.
Shale		200	200
Sand (*Hamden*)		5	205
Shale		65	270
Sand, soft (*Berea*)		60	330
Shales (*Bedford* and *Ohio*)		710	1,040
Limestone	(*Devonian* and *Silurian*)	370	1,410
Shale		20	1,430
Limestone		40	1,470

	Thickness in feet.	To bottom of formation.
Shale	155	1,625
Red rock	11	1,636
Sand, hard, calcareous (*"Clinton"* sand.)	7	1,643
Shale	91	1,734
Sandstone	10	1,744
Shale	56	1,800
Shales and limestone shells (*Richmond* and *Maysville*)	400	2,200

The great beds of Devonian and of Silurian limestones, shown in the above section, are below the average in thickness, while the interval from the Berea sand to the "Clinton", here 1,366 feet, is nearly 300 feet shorter than it is in northern Jackson and southern Vinton counties. The Berea sand has exceptional thickness, but this appears to include a part of the underlying Bedford formation.

In the hollow, north of the cemetery at Stockdale, in Section 33, Marion Township, Stretton and Cole of Lancaster, Ohio, drilled what is reported to be a "Clinton" well. No record of the test was obtained. Neither oil nor gas was found in paying quantities.

BEDFORD SAND WELLS

The Bedford formation, which outcrops along the Scioto Valley in Pike County, is made up of shales with a few widely spaced, thin to medium bedded sandstones, which in most respects are quite similar to those of the overlying Berea formation. Along in the "sixties" a shallow test known as the Taylor well was drilled with a spring pole on the B. Hammond property, in the central part of Section 30, Scioto Township. The head of this well is just above the top of the Sunbury shale. The depth reached by the drill is reported by J. W. Brand to have been about 300 feet. Oil was found, and the well, which was pumped for a time, produced about one barrel of oil per day.

On the R. H. McAuley farm, which adjoins the Hammond property to the west, a well 108 feet in depth was drilled for water, and it gave a showing of both oil and gas in sufficient quantities to spoil the water for domestic use. This well, Mr. McAuley states, was drilled all the way in sandstones, with shales intervening. Along the stream at this place there is found a thick outcrop of the Berea formation which passes below cover only a short distance east of his residence. The McAuley well started near the top of the Berea formation, which in this locality is not more than 60 feet in thickness. The oil found in this test, and also in that on the Hammond property, therefore, appears to be in the sandstone layers near the base of the Bedford formation.

BEREA SAND

The Berea sand which outcrops along the Scioto Valley dips to the east and south, so that it is from 300 to 400 feet, or even more, below drainage by the time it reaches the eastern boundary of the county. So far, no productive fields have been located in this formation. However, it usually gives a showing of oil or of gas wherever penetrated.

In the year 1868 a shallow well was drilled to the Berea sand on the land of William and Fred Sohn, in the western part of Section 28, Marion Township. Mr. Sohn states that this well was about 450 feet deep and gave a small flow of high-grade oil. The well was pumped only for a short time as the production decreased rapidly.

EASTERN HALF OF SCIOTO COUNTY

A search for oil and gas began in Scioto County soon after their discovery in Pennsylvania in 1859, and has continued in a desultory way to the present time. So far, productive fields have not been found, although either oil or gas in small quantities is secured at some horizon in nearly every well that has been drilled. Although the tests of the deep-seated rocks are relatively few and quite scattered, they are sufficient to indicate that no large pools are present. The surface rocks have a rather uniform dip to the east and south, and the deeply covered strata appear to conform to the same general inclination. Map XI, Part 2.

"CLINTON" SAND

The "Clinton" sand has been penetrated by the drill at a number of places in Scioto County, but it has yielded no products of value. In a few localities small flows of gas are encountered on the horizon. A study of the drill records that have passed this formation indicates that the sand lacks definite development and persistent continuity.

In 1910, Stretton and Cole, of Lancaster, Ohio, drilled a well on the Erwin farm, now owned by J. C. Boggs, and located in Section 34, Jefferson Township. The drill started near the base of the Cuyahoga formation, and Mr. Boggs states that it penetrated the rocks to a depth of about 2,700 feet. The test was unproductive. Small flows of both gas and brine are issuing at present (1915).

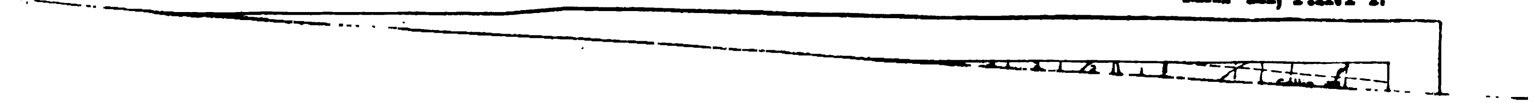
Several attempts have been made in the western part of the county to locate oil or gas in the "Clinton" sand, but so far the results have been discouraging. In 1865 or 1866, J. A. Sands drilled four wells in the vicinity of Bear Creek, and his account of the work is embodied in the following discussion: Two wells were drilled on the Booten farm, which is located about 3 miles up Bear Creek in Morgan Township. In the first well located near the stream a strong flow of salt water was struck at a depth of about 700 feet, but the work was continued until approximately 1,000 feet was reached. The second well, which was drilled on the side of the hill, was practically a duplicate of the first. No gas was found in either test. These wells are listed as "Clinton" tests, for if they did not reach this sand they came very close to it. The "Clinton" bed in this locality is between 1,200 and 1,400 feet below the Berea formation, which outcrops on the hills. However, these tests may have stopped in the Niagaran limestones, only a short distance above the "Clinton" formation. On the G. F. Lauman property, near the mouth of Bear Creek, a test was also made. At a depth of 675 feet there was found a strong flow of gas which ignited and burned the derrick. A new rig was built, and the drilling continued to a depth of 1,150 feet. This test was unproductive. On the Russel farm, now owned by William T. Dever, a well was drilled near the bridge that crosses the Scioto River west of Lucasville. Here the drill went to a depth of 1,188 feet, but it released neither oil nor gas in paying quantities. These two wells are also doubtfully "Clinton," but the drill at least was very close to this formation.

Besides the wells drilled by Sands, three other tests have been made on the G. F. Lauman property. The main points regarding these were furnished by Mr. Lauman. In the year 1890, about one-third mile west of his residence, a well was drilled to a depth of 1,535 feet. A flow of water was encountered at 535 feet, and a second flow at 635 feet. At a depth of 1,050 feet a small flow of oil, which is reported to have made about 2 barrels per day, was found. Below this the drill released a small flow of gas, estimated at 50,000 cubic feet per day, and used by Mr. Lauman for lighting and heating his residence, and also for lighting the premises. This gas is supposed to come from the "Clinton" sand, the position of which is near the bottom of the well. About one mile west of the Lauman residence a test, in which the drill is reported to have penetrated the rocks to a depth of 2,230 feet, was made, and it was productive of only a small flow of gas, which was struck in the "Clinton" sand at about the same depth as that in the well now producing. No oil was found during the entire descent of the drill. Another well about 1,300 feet in depth was drilled near the residence.

In Morgan Township, near the mouth of Sunfish Creek, on the Starr farm, now owned by Mrs. Henry Stahler, a well reported to have reached the "Clinton" sand was drilled, but no production was obtained. On Rocky Fork, in Brush Creek Township, six miles south of Otway, a test was drilled to the deep sands in search of oil and gas. Dr. G. W. Chabot, Portsmouth, Ohio, gave the main facts regarding this work. The drill started immediately below the Berea sand and reached a flow of salt water at 400 feet. Below this the rocks were dry. There was a showing of oil in limestone at 1,600 feet, and a small flow of gas, which is still issuing, at 1,908 feet. Below this, at a depth of 2,045 feet, 10 feet of sand was struck, but it gave no showing of either oil or gas. The total depth of this well was 2,055 feet.

A deep test, which went far below the horizon of the "Clinton" sand, was drilled at the plant of the Harbison-Walker Refractories

MAP XI, PART I.



Company, on Gallia Street, Portsmouth, Ohio. Dr. Orton's description of the test follows:[1]

> The Portsmouth well was drilled in 1885. It was begun in the Cuyahoga shale, and near the base of this stratum. The record is as follows:

	Thickness in feet.	To bottom of formation.
Loam, sand, and gravel	70	70
Sandstone, *Buena Vista* stone	50	120
Shale, black, *Berea*, (now called *Sunbury*)	30	150
Sandstone, *Berea* grit	50	200
Shale, red, *Bedford*	50	250
Shale, mainly black, *Ohio*	560	810
Limestones, *Monroe*, *Niagara*, and *Clinton*	675	1,485
Shale, red, *Medina*	50	1,535
Shales, and limestones, *Hudson River* (*Richmond-Maysville*)	465	2,000

> From samples of drillings, obtained at 885 feet in reaming the well, which are unmistakably water lime or Lower Helderburg, it is judged that the Corniferous limestone is still excluded from the section by the overlap of the Ohio shale. The limestone was found full of salt water, the strongest and most persistent vein being struck at 1,000 feet. The casing was necessarily set deep, viz., 1,120 feet. The well was carried down into the Hudson River, or Cincinnati group, but it stopped short of the Trenton. No gas bearing rocks of high-pressure were found in the descent, though more or less gas was struck in every stratum.

So far, the only deep drilling in the eastern townships of Scioto County was done on Frederick Creek, in Section 20, Bloom Township, in the year 1898, by T. N. Barnsdale. The well is located on the property of the Harbison-Walker Refractories Company. The drill started in the Sharon conglomerate, close to the contact of this stratum, with the Logan sandstone below, or about 35 feet below the Sciotoville clay, and reached a depth of 2,317 feet. Paul Williams kept a carefully made record of the rocks penetrated by the drill in its descent, and his report is used freely in the following description: The hole was begun with a 13-inch bit and was spudded down to 100 feet, passing through soil, gravel, conglomerate, and sandstone with water. The 13-inch bit was used to 160 feet, after which a 10-inch bit was employed. It passed through the dark colored Waverly shales, and at 520 feet struck the Berea sand, which produced gas in sufficient volume to give a flame 10 feet high. The gas was cased off and an 8-inch bit used. It passed rapidly downward, sometimes at the rate of 200 feet per day, as it was now in the great Ohio shale stratum, which varied from a soft white substance to one that was dark, hard, and sandy. At 1,200 feet, in a dark hard stratum, a little oil was seen.

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[1] Geol. Surv. Ohio, Vol. VI, p. 395. In the above the second column of figures, and the terms in parentheses were supplied by the writer.

This bed is close to the horizon of the gas bearing sand in which the wells of the Ironton Portland Cement Company obtain their production.

At 1,300 feet, the great body of Ohio shale ended, and the Devonian limestones were struck. At first, the material was soft and shelly, but it grew darker, harder, and more compact as the drill descended. Within the limestone deposits there was found a great quantity of exceedingly salty water, which was strongly alkaline, and which filled the well nearly to the top. At 1,500 feet, a flow of crevice gas was struck, and, even on the following day, it forced the water from the hole to a height of 20 feet, at intervals of 2 or 3 minutes. The hole was cased with 6-inch tubing to a depth of 1,710 feet, but this failed to cut off the water. At 1,840 feet the limestones ended, and the drill entered the Niagaran shales. The casing was reset, and the hole remained dry.

Drilling was now rapid. At 2,040 feet the "Clinton" sand, with its characteristic red sands, was found, but it was wholly barren of gas. At 2,160 feet the red shales of the Medina, the red rock of the drillers, were found, and they continued for 40 feet. Thence came dark shales of the Richmond formation, and at 2,317 feet the drilling ended. The drillers' record, simplified somewhat, follows:

	Approximate thickness in feet.	To bottom of formation.
Soil, gravel, conglomerate, and sandstone	100	100
Shales, dark, *Logan*, *Cuyahoga*, *Sunbury*	420	520
Sandstone, *Berea*, with gas at 520	810	1,330
Shales, *Bedford* and *Ohio*, with oil at 1,200		
Limestones, *Devonian* and *Silurian*, with gas at 1,500 feet	510	1,840
Shales, soft, white	60	1,900
Shales, soft, blue	140	2,040
Limestone at 2,040	160	2,200
Red rock at 2,050, "*Clinton*" sand		
Shale at 2,100		
Limestone and sandstones at 2,120		
Limestone at 2,140		
Shale at 2,160		
Limestone and shale, *Richmond*	117	2,317

BEREA SAND

In the eastern part of Scioto County the Berea sand has been exploited in a few places for oil or gas, but so far it has yielded little return for the money and labor invested. The early drilling began about 1860, when the spring pole was the tool employed. The sand has excellent continuity, for it appears in all the well kept records that have been extended to or below this horizon. The Berea sand lies from 600 to 800 feet above the upper surface of the thick beds of Devonian limestones, and from 500 to 600 feet below the base of the Pottsville rocks. However, on the whole, the tests of this sand are discouraging. A list of the wells drilled to the Berea sand follows:

In the city of Portsmouth, on Jackson street, near Campbell avenue, a test well was drilled by Grove Brothers of Tionesta, Pennsylvania. Herman Spitzer reports that the drill reached a depth of about 800 feet, which is much below the horizon of the Berea formation. Neither oil nor gas was secured in paying quantities. North of Portsmouth, in an attempt to develop a small oil pool in the Berea sand, a number of shallow wells have been drilled, but the results are not especially successful. The work in most part has been done by Grove Brothers. Aaron Bobst reports that the oil sand is found at a depth varying from 380 to 390 feet, while a salt sand, lying above, occurs from 350 to 360 feet below the surface. The wells mapped are given below:

One in Rosemary addition, Portsmouth.
Three on the W. R. Micklethwait property in Section 9, Clay Township.
One on the Samuel Timmonds property in Section 9, Clay Township.
One on the Havecotte Brothers property in Section 9, Clay Township.
One on the Martin Suter property in Section 9, Clay Township.
Four on the William Darmon property in Section 9, Clay Township.
One on the Isaac Noel property in Section 8, Clay Township.
One in the Kinney Lane addition in Section 8, Clay Township.
One on the T. Crick property, Brewery Hollow, Section 10, Clay Township.

One of the wells on the William Darmon farm was pumped for a short time, while several others gave a showing of oil.

In 1890, Overturf and McCall put down a well to the Berea sand, on the land of Martin Scherer, in Pleasant Valley, Section 3, Clay Township. Mr. Scherer states that this well was about 300 feet in depth and that it gave a showing of oil. Another well was drilled north of this, on the farm of R. P. Siler, in the northwest corner of the same section. In this test also a showing of oil was obtained. Along in the "sixties," a shallow test, which evidently reached the Berea sand, at least, was drilled with a spring pole on Munn Run, just north of the Portsmouth-Ironton pike. No oil was obtained, but small quantities of gas are yet emitted.

In 1875, on the site of the Lower Yard of the Scioto Fire Brick Company, at Sciotoville, W. Q. Adams made a test which went below the horizon of the Berea sand. Charles Turner states that the well was first drilled to a depth of 1,000 feet, but later extended to 1,500 feet. About 500 feet down, a small flow of gas was struck in the Berea sand and was used under the boilers for a time, but, owing to imperfect casing, the water was not excluded, and the well was finally abandoned. Near the old stack of Bloom Furnace, in Section 30, Bloom Township, a shallow well was drilled many years ago. It produced a small flow of gas which was used for a time in lighting the east house of the furnace. Fred Worthington reports it to be 683 feet in depth, which interval is probably sufficient to reach the Berea sand.

LAWRENCE COUNTY

The high market price of crude oil during the "sixties" started drilling in Lawrence County, but the rewards, so far, have not been equal to the expenditures. Although the tests are widely scattered, there yet exist large areas in which there is some hope of securing these valuable natural hydrocarbons. Moreover, there are several well defined sands in this area, which have ample covering and the necessary physical structure to act as storage reservoirs for oil or gas. The Ironton Portland Cement Company, near its plant at Ironton, developed a small gas field which is an asset of considerable value. A showing of oil was obtained near Willowwood, while small quantities of gas have been struck by the drill at a number of places. The general dip of the surface rocks is 25 feet to the mile east, and 9.5 feet to the mile south, while the strike is 20° 48′ east of north. Abnormalities in the dip of the surface strata are found, for in some localities for a short distance the rocks dip at a rate as high as 45 feet or even more to the mile, while at other places for a few miles they dip not more than 15 feet. The general trend of these structural features is nearly parallel with the strike of the rocks. As yet no detailed work has been done to determine with accuracy the configuration of either the surface or the deep-seated rocks. Map XI, Part 2.

TRENTON LIMESTONE

The Trenton limestone, which is one of the most important oil rocks in Ohio, was reached by the drill at one place in Lawrence County. This was in the Belfont well at Ironton. The history and description of this well as given by Dr. Edward Orton follows:[1]

> The record of the Ironton well (in the Ohio Valley, in Lawrence County), upon which a large expenditure has been made, is of considerable interest as marking the deepest point at which the Trenton limestone has been reached in the State (1887). It seems probable that this great stratum was struck at a depth of 3,440 feet. The upper portion of this record is very clear and intelligible, but the record of the lower half is less satisfactory. The latter condition results from lack of material and not from any anomalous or unexpected facts. The section appears to be normal throughout.
>
> The well was begun in the Conglomerate Coal Measures near the upper Mercer coal level and 145 feet below the level of the Ferriferous limestone. It is a little less than 550 feet above tide. . . . .
>
> It was not originally directed to the Findlay gas-rock, but it was simply drilled to test the ordinary range of rocks of this region. After the Berea grit, which was struck at 1,028 feet, had proven unproductive, the bold plan was formed of drilling the well to the Trenton limestone, this last horizon having become prominent at this time. The record is as follows:

		Ft.
1.	Surface and shale	65
2.	Sandstone	14

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[1] Geol. Surv. Ohio, Vol. VI, pp. 304-306.

		Ft.
3.	Coal, thin, at 79 feet Fire clay	3
4.		
5.	Blue shale	112
6.	Conglomerate stratum	8
7.	Blue shale	30
8.	Hard white sandstone	10
9.	Dark blue shale	40
10.	Sandstone and conglomerate, with many alternations	300
11.	Blue shale	30
12.	Dark sandstone, fine-grained	30
13.	Blue shale, with occasionally thin courses of sandstone	348
14.	Black shale	20
15.	White sandstone, fine-grained	47
16.	Shale	60
17.	Sandstone	15
18.	Red shale	15
19.	Dark shale, mainly black	570
20.	Light blue shale, alternating with black	110
21.	Limestone of various shades and grades	584
22.	Green shale, interbedded with red rock	336
23.	Shale, with limestone bands	695
24.	Trenton limestone counted as beginning here	3,440
25.	Drilling suspended at	3,600

The interpretation of this long record is for the most part obvious and unmistakable. The record can be condensed as follows:

	Ft.
Coal measures	282
Logan group and Cuyahoga shales	728
Berea grit	47
Bedford and Ohio shales	770
Upper Silurian limestone	584
Medina, Hudson River, and Utica shales	1,000 to 1,100

"CLINTON" SAND

The rocks of the "Clinton" formation have been reached by the drill in Lawrence County, but, where penetrated, have been wholly barren of either oil or gas. The sand of this formation is not sharply defined but its horizon appears to lie on the average about 200 feet below the base of the massive body of Silurian limestones. Besides the Belfont well, where the drill reached the Trenton limestone, only two tests have been made in Lawrence County to or beyond the horizon of the "Clinton" sand. One of these is at the plant of the Ironton Portland Cement Company southeast of Ironton, and the other is at Mount Vernon Furnace in Decatur Township.

In 1906, the Freehold Oil & Gas Company, of Campbell, Ohio, drilled a deep well on the land of Harry Moulton. The well is located near the pike, about 1 mile south of Campbell Post Office, Decatur Township. The interval from the top of the well to the Ferriferous limestone is 38 feet. The record furnished the Survey by Mr. Moulton is as follows:

		Thickness in feet.	To bottom of formation.
Surface		17	17
Quicksand		3	20
Sandstone		110	130
Coal		4	134
Shale, black		205	339
Shale, white		14	353
Limestone, (*Maxville*)		96	449
Sandstone, pink		15	464
Sandstone		436	900
Shale, black		64	964
Shale		36	1,000
Shale, black		95	1,095
Sandstone, (*Berea*)		25	1,120
Shale, black		430	1,550
Shale		260	1,810
Limestone, soft	(*Devonian* and *Silurian*)	150	1,960
Limestone, hard		470	2,430
Shale, black		19	2,449
Limestone, shaly		29	2,478
Shale, chocolate		117	2,595
Shale, white		60	2,655
Rock, pink, (horizon of "*Clinton*" sand)		15	2,670
Shale, white		20	2,690
Shale		20	2,710
Limestone		9	2,719
Rock, red		11	2,730

A small flow of water was found at a depth of 130 feet, and a strong flow was encountered at a depth of 2,240 feet. The casing used in the work follows:

Conductor	20 feet.
10 inch casing	353 feet.
8 inch casing	961 feet.
5 3-16 inch casing	2,245 feet.

So far the three tests in Lawrence County which have with certainty passed below the horizon of the Clinton sand, have failed to show a well defined stratum of oil or gas bearing rock. The interval appears to be made up of shales in which little or no porous sandstone is present. From the data at hand, which is rather meager, but is strengthened by the work in eastern Scioto, southern Jackson, and northern Gallia counties, it appears that if production is found, the pools will be confined to rather small and somewhat isolated lenses of sand enclosed in the shales.

IRONTON GAS SAND

In ascending order, the next rock above the "Clinton" in which production has been obtained is a gas bearing stratum lying in the body of the Ohio shales. In this report it is called Ironton gas sand, simply to distinguish it from other beds, and not to define any new stratigraphic unit. The position of the Ironton gas sand is about 570 feet below the top of the Berea formation and about 280 feet above the top of the Devonian limestones. Albert Steece, general manager of the Ironton Portland Cement Company, states that the gas producing bed is thin, not to exceed a few feet in thickness, but is well defined over the small area tested. The wells with a rock pressure of approximately 600 pounds produce on the average about 150,000 cubic feet of gas each per day. The log of the Ironton Portland Cement Company's well, No. 1, which was drilled at the works in the year 1912, is as follows:

	Thickness in feet.	To bottom of formation.
Not recorded	179	179
Sandstone	15	194
Limestone	1	195
Shale, black	122	317
Sandstone	54	371
Sandstone	6	377
Rock, red, (*Sciotoville* clay horizon)	7	384
Not recorded	24	408
Sandstone, *Maxton*	25	433
Not recorded	1	434
Limestone, *Maxville*	97	531
Shale, white and black	72	603
Sandstone	57	660
Shale	486	1,146
Shale, coffee colored, (*Sunbury*)	20	1,166
Sandstone, hard and broken, *Berea*	75	1,241
Not recorded	6	1,247
Shale, gray and black	489	1,736
First gas Sandstone Main flow of gas } (*Ironton* gas sand)	----	1,744
Bottom of well	----	1,746

As the Ironton gas sand produced gas in commercial quantities, the well was tubed with 3-inch piping to a depth of 1,746 feet, with the packer set at 1,740. In the above log, the terms in parentheses were supplied by the writer.

A producing well was drilled south of the road at the works, and a dry hole near the mouth of the hollow one-half mile northeast of the plant. Production was obtained in the test located at the forks of the road one-fourth mile west of the plant, and also in the well drilled on the west bank of Ice Creek, only a short distance south of the bridge that crosses this stream. Another well drilled by this company, north of the road, near the northeastern corner of Woodland Cemetery, also produces a good flow of gas. G. H. Welch of Ashland, Kentucky, obtained production in the Ironton gas sand just south of the bridge and east of Ice Creek. At the mouth of Hog Run, a northern tributary of Ice Creek, and about one mile east of the producing territory near the plant of the Ironton Portland Cement Company, a dry hole was drilled to the sand on the land of the Hecla Iron Company. The well head here is about 70 feet below the Ferriferous limestone. The areal extent of the Ironton gas sand is not defined by the few tests made in Lawrence county, for production is obtained near Ashland, Kentucky, on this horizon. It may correlate, also, with the gas bearing beds found farther south in Greenup and Boyd counties.

BEREA SAND

The next oil or gas bearing bed in the ascending scale is the well-known Berea sand, which is found by the drill everywhere in the area treated in this report. Although penetrated by the drill at widely separated places in Lawrence County, this sand has failed to produce more than a showing of either oil or gas.

In Peters Cave Hollow, near Bartles, in Elizabeth Township, E. B. Willard drilled three tests to the Berea formation, which were barren of either oil or gas in paying quantities. The sand was present in each of the wells, but it seemed to be hard and broken. The overlying Sunbury shale is well defined, and the Hamden sand is also present and is productive of small flows of gas.

The Willard well, No. 1, which was drilled in 1889, is located near the village of Bartles at the mouth of a branch of Little Pine Creek. The well was started about 5 feet above the Upper Mercer ore, or about 95 feet below the base of the Ferriferous limestone. The core drill was used to a depth of 263 feet which interval is, therefore, recorded with accuracy. The log of the well taken by Mr. Willard, who kindly furnished the Survey a copy, follows:

	Thickness in feet and inches.		To bottom of formation.	
Drift	5	--	5	--
Shale, blue	19	--	24	--
Shale, black	3	6	27	6
Coal	1	--	28	6
Clay	1	--	29	6
Shale, siliceous	12	--	41	6
Coal	---	3	41	9
Clay	1	--	42	9
Sandstone, shaly	12	--	54	9
Sandstone, dark, shaly	28	6	83	3
Coal	---	6	83	9
Shale, dark	8	4	92	1
Coal	1	--	93	1
Shale, dark	12	8	105	9
Coal	---	1	105	10
Sandstone, fine-grained	4	--	109	10
Shale	1	--	110	10
Coal	---	3	111	1
Shale, dark	16	--	127	1

	Thickness in feet and inches.		To bottom of formation.	
Sandstone	37	--	164	1
Shale, dark	3	--	167	1
Sandstone, shaly, white	18	--	185	1
Shale, dark	7	--	192	1
Coal	---	5	192	6
Shale	5	--	197	6
Sandstone, shaly	11	--	208	6
Shale	1	6	210	--
Coal	1	--	211	--
Shale, dark	18	--	229	--
Shale, dark, with sulphur balls	25	--	254	--
Clay, siliceous	2	6	256	6
Fire clay, No. 1	6	6	263	--
Sandstone, hard, white	20	--	283	--
Sandstone, soft, white, with salt water	127	--	410	--
Shale, white	15	--	425	--
Clay, red (*Sciotoville*)	7	--	432	--
Sandstone (*Maxton*)	38	--	470	--
Limestone (*Maxville*)	15	--	485	--
Sandstone	20	--	505	--
Sandstone, shaly, with limestone mixture	80	--	585	--
Shale, gray	40	--	625	--
Sandstone, gray, hard	15	--	640	--
Shale, gray	260	--	900	--
Shale, hard, with gas (*Hamden*)	5	--	905	--
Shale, gray	115	--	1,020	--
Shale, black	30	--	1,050	--
Sandstone, *Berea*	53	--	1,103	--
Sandstone, white	92	--	1,195	--
Shale, black	49	--	1,244	--

The terms in parentheses were supplied by the writer.

In this test the Berea sand was wholly barren, but an overlying sand which appears to be correlative with the Hamden bed gave a small flow of gas. In 1902 the Willard well, No. 2, was drilled near the head of Peters Cave Hollow, or about one and one-half miles east of the village of Bartles. This test was started about 10 feet above the top of the Lower Kittanning coal and reached the Berea sand at a depth of 1,220 feet. The sand was 37 feet in thickness and unproductive. However, the Hamden sand, which was about 200 feet above the Berea, gave a showing of gas. In the third well drilled in 1913, and located near the lime crusher in Peters Cave Hollow, the Berea formation, 31 feet 6 inches in thickness, was struck at a depth of 1,106 feet, but it contained neither oil nor gas in paying quantities.

Near the headwaters of Little Ice Creek, in the central part of Perry Township, and about one mile south of the village of Dearing, two wells have been sunk to the Berea sand. The first well was drilled by the Clover Leaf Oil & Gas Company, the main stockholders of which were J. A. Salmon, M. R. Haymaker, and H. Packer. Concerning this test Mr. Salmon states that in the well which was drilled on the William Baker farm the Salt (Maxton) sand was reached at a depth of 662 feet and gave a nice showing of gas. The drill struck the Berea formation at a depth of 1,245 feet, but released only a showing of oil. The sand was very hard. The Sunbury or coffee-colored shales overlying the Berea sandstones were between 20 and 30 feet in thickness. A second test of the Berea sand was made on the Baker farm by G. L. Titus and J. W. Ramsey, of Huntington, West Virginia, in the year 1915, but neither oil nor gas was found. The operators report that there was no showing of oil in any sand.

Several Berea wells have been drilled in the vicinity of Willowwood, in Lawrence County. For much of the information in regard to these the Survey is indebted to William Holschuh. In the northern part of Section 18, a test to the Berea sand was drilled near the residence of Mr. Holschuh. The contractor, B. F. Cayton, of Weston, West Virginia, is authority for the following log:

	Thickness in feet.	To bottom of formation.
Quicksand	60	60
Shale, blue	65	125
Sandstone, showing of oil	85	210
Shale, black	190	400
Sandstone, showing of gas	10	410
Sandstone	50	460
Shale, black	210	670
Sandstone, oil bearing, (*Maxton*)	40	710
Shale, black	10	720
Sandstone with water at 760	320	1,040
Limestone, broken, (evidently sandstone)	60	1,100
Sandstone	25	1,125
Shale, with pencil cave	10	1,135
Limestone shells, (evidently sandstone)	85	1,220
Sandstone, broken	85	1,305
Shale, light	225	1,530
Limestone shells, (*Cuyahoga* sandstones)	20	1,550
Shale, brown, (*Sunbury*)	17	1,567
Sandstone, *Berea*, showing of oil	18	1,585
Total depth		1,615

The terms in parentheses were supplied by the writer.

Just north of the mouth of Venisonham Creek, on the Tom O'Neil property, a Berea well was drilled by M. Haymaker. It produced a strong initial flow of gas in one of the Pottsville sands, which, however, soon flooded with water, thus eliminating the flow of gas. From information furnished by A. B. Brode, of Huntington, West Virginia, the Berea sand, 30 feet in thickness, was struck at a depth of 1,535 feet and gave a showing of oil. A Berea test was bored by M. Haymaker at the forks of the road, on Venisonham Creek, and its eastern tributary in the western part of Section 17, Windsor Township The well is located on the land of William Holschuh, who reports that a showing of oil was found in the Berea sand, and also shows of both oil and gas in more shallow sands, probably Pottsville. Just east of this test and also on the same property, another well was drilled to the Berea sand, but no production was obtained. However, one of the shallow sands gave a showing of oil. On the property of Asa McCoy in the northwestern part of Section 8, Windsor Township, a well reported 1,800 feet in depth was drilled on Venisonham Creek. The drill in this test evidently passed below the horizon of the Berea formation. The rocks are reported to be wholly barren of either oil or gas. On the farm of J. W. Payne, east of Symmes Creek, and in the northern part of Section 19, Windsor Township, the drill is reported to have penetrated the Berea sand which was dry. This test is located on the small terrace only a short distance east of Symmes Creek. Near the village of Scottown, in the eastern part of Windsor Township, the search for oil and gas also led to the drilling of a well that reached the Berea formation. The Scottown well is located near the bank of Little Indian Guyan Creek, on the property of John Burcham, and was drilled in 1903, by Charles H. Hall, of Huntington, West Virginia. The test was unproductive, although the Berea sand was found in good volume. Near the village of Getaway, a test of the Berea sand was made on the land of J. W. Gerlach, in the northwestern part of Section 8, Union Township. The well is located on the north bank of Symmes Creek and was drilled by Cole, Enslow, Walton, and Hall of Huntington, West Virginia. The drill started 15 feet below the Cambridge limestone and at an elevation of 555 feet above tide. From a partial record furnished by A. B. Brode of Huntington, the following information was obtained: The Salt sand was reached at a depth of 740 feet, and a limestone, evidently Maxville, at a depth of 830 feet. The top of the Berea sand, which was 20 feet in thickness, was struck at a depth of 1,615 feet. Further, the total depth of the well is stated to be 1,675 feet and the test unproductive. At present there are small flows of gas and salt water to mark the location.

In 1915, A. B. Brode, of Huntington, drilled an unproductive Berea well in the eastern part of Section 23, Union Township. No information in regard to the rocks penetrated by the drill was obtained. Near the Finley Church, on Paddy Creek in Rome Township, a test for oil or gas was made on the property of Charles Farley, who reports that the well was drilled to the Berea sand, which was reached at a depth of 1,985 feet. A showing of oil was found in the Berea, and a small flow of gas was released in a bed above this horizon.

In order to extend the Berea sand to the Ohio River, and to follow some of the higher sands and other well-defined members to deeper cover, a record of a well drilled on the C. S. Winters farm on Seven-mile Creek, in Caball County, West Virginia, is given below. A. B. Brode of Huntington is authority for the log:

		Thickness in feet.	To bottom of formation.
Soil		30	30
Gravel		4	34
Not recorded		169	203
Sand		21	224
Not recorded		291	515
Sand		133	648
Coal		4	652
Not recorded		51	703
Sand		47	750
Not recorded		35	785
Sand		21	806
Not recorded		14	820
Sand		10	830
Not recorded		72	902
Coal		4	906
Not recorded		11	917
Sand		15	932
Not recorded		42	974
Sand		12	986
Not recorded		85	1,071
Sand, *Salt*		129	1,200
Red rock		13	1,213
Not recorded		10	1,223
Sand, *Maxton*		8	1,231
Not recorded		15	1,246
Limestone, *Little Lime*	(*Maxville*)	11	1,257
Not recorded, pencil cave		5	1,262
Limestone, *Big Lime*		153	1,415
Sand, *Keener*		33	1,448
Not recorded		11	1,459
Sand, *Big Injun*, with water at 1,462 feet		121	1,580
Not recorded		440	2,020
Sand, *Berea*		12	2,032
Total depth			2,080

The term in parenthesis was supplied by the writer.

In Lawrence County, the drill has reached or passed the Berea rocks 26 times, but, so far, has failed to reveal either oil or gas in paying quantities. Small flows of gas and showings of oil are often recorded by the driller, but in many cases streams of salt brines were the only reward for the money and labor invested. The sand, however, was present in every test, and with few exceptions has excellent volume.

MAXTON SAND

The Maxton sand lies either directly or only a short interval above the Maxville limestone, and is in the lower part of the Pottsville formation. It is correlated with the Sharon or Olean conglomerate, which is well exposed in southern Ohio, especially in northern Scioto, in western

Jackson, and in eastern Pike counties. In these localities the member is composed of massive beds of quartz conglomerate, often more than 100 feet in thickness, with more or less interstratified coarse-grained sandstones. However, in local areas, it may appear as a sandstone with but few if any pebbles. In the Willowwood field, the sand in which the main showing of oil was obtained is correlated with some confidence as the Maxton sand or the Sharon conglomerate. Although the Maxville limestone is doubtfully present in the recorded measurements of the rocks in this field, it is massively developed in the Baker farm well, which is located south of Dearing, and which, on a direct line, is less than five miles distant.

The record of the Mootz well No. 6, drilled by J. F. McElroy on the hillside about 150 feet west of Symmes Creek, was kindly furnished by Mr. McElroy, and is given below:

	Thickness in feet.	To bottom of formation.
Soil	27	27
Shale	58	85
Sandstone	20	105
Shale	65	170
Sandstone	170	340
Shale	35	375
Sandstone	40	415
Shale	10	425
Coal	2	427
Shale	75	502
Sandstone	42	544
Shale	91	635
Sandstone, *Nagel* sand, (*Middle Salt*)	20	655
Shale	43	698
Sandstone, oil sand, (*Maxton*)	2	700
Shale	5	705
Sandstone	7	712
Bottom of well	--	712

A showing of oil was found in the Nagel sand at a depth of 640 feet, and a small flow of oil was obtained in the sand at 700 feet. Water was struck at a depth of 522 feet, at which position the casing was set.

On the same property and close to Symmes Creek, A. P. Meek, of Parkersburg, West Virginia, drilled a test to the Maxton sand. The well was pumped for a short time and is reported to have had an initial production of 6 barrels of oil per day. The flow rapidly decreased and the well was soon abandoned. On the flood plain of Symmes Creek two other Maxton sand wells were drilled on the same property. Both gave a showing of oil but were never pumped. Two tests, also located close to Symmes Creek, and near the southern boundary of the Dan Mootz farm, produced a small quantity of oil, but were soon abandoned. The seventh well drilled on this land is located on the side of the hill about 300 feet west of Symmes Creek, and was drilled in the year 1914 by J. F. McElroy. The Nagel or Middle Salt sand, 28 feet in thickness, was found at a depth of 619 feet, and the Maxton sand, penetrated only 4 feet 6 inches, was struck at 689 feet. In this test water was found at 165, at 245, and in a coal bed at 595 feet, respectively. The casing was set at 602 feet. Mr. McElroy states that the Nagel sand made about one-half barrel of oil per day before shooting, and about one barrel after it was loosened by explosives. The oil in this sand was found at a depth of 630 feet. The lower or Maxton sand made about one-half barrel of oil per day.

Three Maxton sand wells were drilled on the W. H. Bame farm, located just south of the Dan Mootz property at Willowwood, or just west of Symmes Creek, in the northern part of Section 19, Windsor Township. The Bame No. 2 well, which is considered the most productive test in this area was drilled in the year 1912, and B. F. Cayton states it had an initial production of 30 barrels of oil per day without shooting. The well was pumped only a short time as the flow of oil decreased rapidly. Another test on this property was made in a small hollow and only a short distance west of the well which was put down by Mr. Cayton. Both the Maxton and the Nagel sands were dry. The Bame No. 3 well was drilled by J. F. McElroy in 1914, and is located just north of Mr. Bame's residence. A showing of oil was secured in the Nagel sand at a depth of 615 feet. The initial production of the Maxton sand was 4 barrels of oil per day, but after one week the flow was only 1½ barrels.

A Maxton sand well was drilled on the property of Sarah Jane Hayes, which is located just east of the village of Willowwood. The test was unproductive, but showings of oil were secured. North of this village, on the land of Sherman Corn, a test was made, but the Maxton sand was not found; hence no results were obtained. Just north of Millville, in the southern part of Section 7, Windsor Township, an unproductive test of this sand was made on the property of John Wilson. Up a small hollow east of Millville, on the land of Jacob Holschuh, the drill penetrated the Maxton sand, which is reported to be quite thick, but released neither oil nor gas in paying quantities. Due east of the bridge that crosses Symmes Creek at Willowwood, on the property of William Holschuh, the test reached the Maxton sand at about 650 feet but was unproductive. Just east of this well, at the base of the hill, the drill again penetrated this sand and released a strong flow of gas. Drilling was continued until another sand producing only brines was struck. The flow of water eliminated the gas. On the side of the hill east of this a third test was made, but the Maxton sand was barren of either oil or gas in paying quantities. North of the Venisonham Creek road, in the eastern part of Section 18, Windsor Township, on the farm of Edward Gruber, an unproductive test of this sand was made.

On the Tom O'Neil farm near the mouth of Venisonham Creek two tests to the Maxton sand were drilled. Notes on the test made on the flood plain just east of Symmes Creek were furnished by Charles H. Hall, of Huntington, West Virginia. A sand with salt water, and 60 feet in thickness, was struck by the drill at a depth of 315 feet. Below this came 285 feet of shale, and then the Maxton sand at a depth of 660 feet. It gave no showing of oil, but a small flow of gas. A second test of this sand gave no results worthy of consideration.

Five Maxton sand wells were drilled on the farm of J. W. Payne, which is located east of Symmes Creek in the northern part of Section 19, Windsor Township. On the flood plain of Symmes Creek, near the northern boundary of the property, an unproductive well was drilled. South of this only a short distance, another test from which a small quantity of oil was pumped was drilled to the Maxton sand, which, from notes furnished by A. B. Brode, of Huntington, was reached at a depth of 676 feet. The bottom of the pay is reported at 682 feet. The workmen state that after drilling deeper they found 3 feet of white sand and 7 feet of coarse gray sand, in which there appeared to be some oil. The bottom of this lower sand was found at a depth of 703 feet, and the total depth of the well was 713 feet. The well was cased with 6¼ inch tubing to a depth of 540 feet. Another test located south of the above, and on the narrow part of the flood plain east of Symmes Creek, also went to the Maxton sand. No results were obtained. In another well drilled along this stream near the southern boundary of the property the drill failed to release either oil or gas in this rock. The stratum was dry, also, where penetrated by the drill just west of the road in the northeastern part of Section 19, Windsor Township.

Two wells to the Maxton sand were drilled on the farm of Charles Dement, which is located in the western part of Section 20. The well drilled close to the little stream near his residence produced a small quantity of oil, but the second test, drilled just south of the first, gave only a showing of this much sought for product. Near the bend, in Symmes Creek, in the northern part of Section 30, Windsor Township, and on the farm of John Russel, an unsuccessful attempt was made to find oil in the Maxton sand. This is the most southern well drilled in the Willowwood field.

On the Adkins farm, on Little Ice Creek, and about 2 miles south of Dearing, a well was drilled by Hummel, of Smith's Ferry, through the Maxton sand, but not to the Berea formation. J. A. Salmon, of Portsmouth, Ohio, states that this test is about 1,000 feet in depth, and that a strong flow of gas was found in the Salt or Maxton sand. The gas was in the very top of the bed, the lower part of which was filled with brines. The productive part of the sand soon flooded with brine, thus eliminating the flow of gas. A shallow test was drilled over 30 years ago on the land of Charles Hart, which is located about 1 mile northeast of the village of Rock Camp. No information regarding the rocks penetrated in this test was obtained, but the drill probably reached the horizon of the Maxton sand; hence, it is listed as a Maxton sand well. No production was obtained. Well towards the headwaters of Middle Paddy Creek, in Rome Township, a well was drilled by Charles H. Hall and others, in 1902. The test is located on the property of Mrs. C. H. Turley and daughters. It was the intention of the operators to drill to the Berea sand, but at a depth of 1,050 feet the tools became fastened and the work was abandoned. The drill reached the horizon of the Maxton sand but released neither oil nor gas.

In Lawrence County, 57 tests have been drilled to or below the horizon of the Maxton sand which, so far, has produced only shows of oil and gas.

MIDDLE SALT OR NAGEL SAND

The next sand in ascending order in which a showing of oil or gas has been secured in Lawrence County lies about 50 feet above the Maxton sand, and is on the average, nearly 25 feet in thickness. The interval from the upper surface of the bed to the Maxville limestone, or to the top of the Logan formation when the limestone is absent, is about 105 feet. Its stratigraphic position is between the Quakertown coal and the Sciotoville clay. A number of the wells drilled to the Maxton sand in the Willowwood field produced a showing of either oil or gas at the Middle Salt sand horizon, but as these have been considered under the heading Maxton sand, they will not be further noticed here. Only one test, the object of which was to exploit the Middle Salt or Nagel sand, was made in Lawrence County, and this was on the farm of Sarah J. Hayes near Willowwood.

In the few tests made in eastern Lawrence County, the Middle Salt or Nagel sand is not defined, but it appears as a well marked stratum in the Gallipolis well, and in many of these drilled in Caball and Mason counties, West Virginia. As the name implies, it is often filled with salt brines. The bed has sufficient covering, and the sand the necessary porosity to be a reservoir for oil or gas, but whether this is, or is not the case in Lawrence County, remains to be determined by future work with the drill.

UPPER SALT SAND

The stratigraphic position of the Upper Salt sand is between the Quakertown and Lower Mercer coals. However, instead of being one definite bed it may be any one of several sandstone strata that may occur in this interval. The evidence from drill records shows that the member is rather persistent in the eastern part of Lawrence County, and that it extends into Gallia County and into Caball and Mason counties in West Virginia. The bed is about 25 feet in thickness and is separated from the Maxville limestone or the top of the Logan formation, where the limestone is absent, by an interval of approximately

210 feet. In Lawrence County it has been exploited mainly in drilling for the deeper seated sands. No production has been obtained on the horizon.

GALLIA COUNTY

The search for oil and gas in the western part of Gallia County has led to the drilling of a number of wells, two of which extend to the horizon of the "Clinton" sand. The main rock exploited, however, is the Berea, which is reached at more moderate depths. So far, neither oil nor gas has been secured in commercial quantities, although one or both in trifling amounts are often recorded by the driller. In the eastern part of the county, the search began in 1861, but the first productive well was completed in 1865. Since then a small field has been developed in Addison and Cheshire townships. In this report only the wells drilled in that part of Gallia County west of a line drawn from north to south through Gallipolis will be considered.

"CLINTON" SAND

The horizon of the "Clinton" sand has been penetrated by the drill in only two places in that part of Gallia County under discussion. From the results obtained in these wells and from those drilled to this formation in eastern Scioto and Lawrence counties, it appears that the prospects for good production are rather discouraging. The "Clinton" sand is deeply covered everywhere in this county, as it is over 3,000 feet below the surface along the western boundary.

The Vinton Oil Company of Lima drilled a deep test on the land of Richard Hardsook, which is located on Deer Creek in Section 34, Huntington Township. The depth penetrated by the drill and reported to the Survey by A. Sailor, a resident of the vicinity, was 3,260 feet, which depth is sufficient to reach the horizon of the "Clinton" sand. Further, he states that there was a showing of oil in a sand at a depth of about 1,800 feet, which would be close to the horizon of the Berea formation. The well head is just below the level of the Upper Freeport coal.

Another test of the deep-seated rocks was made in the year 1914, on the D. D. Lewis farm in Section 28, Greenfield Township. The well was drilled jointly by Gates, Davidson, Moran and Company, of Lancaster, Ohio, and by The Planet Oil Company of Columbus. The following partial log of the well was furnished the Survey by M. C. Miller of the latter company:

	Depth in feet.
Top of limestone (*Devonian* and *Silurian*)	2,212
Big water	2,692
Bottom of limestone	2,857
Top of shells	3,043
Sand, "*Clinton*"	3,084
Total depth	3,220

Fred W. Crawford, of Columbus, Ohio, furnished some additional information in regard to this test. He states that the Salt sand was struck at a depth of 670 feet, and that the Berea sand was found at a depth of 1,257 feet. The head of this well is near the horizon of the Middle Kittanning coal.

IRONTON GAS SAND

Ascending the geological column, the next productive bed found in southern Ohio is the Ironton gas sand, which lies well up in the body of the thick deposit of Ohio shale. This formation has been passed by the drill only 3 times in Gallia County. The two "Clinton" wells previously discussed and the well at Gallipolis extend much below the stratigraphic position of the gas bearing stratum found at Ironton. A white sandstone, which is about 3 feet in thickness and which was reached at a depth of 2,458 feet in the Gallipolis well, appears to be a correlative bed. At least, it is on the same general horizon; hence, it is considered under the above heading. The well was drilled on Chickamauga Creek near Mills Station, in the northern part of Section 6, Green Township.

	Ft.		Ft.
Conductor	53	to	53
Sandstone, brownish, coarse	32	to	85
Shale and black sand	240	to	325
Coal, (some heavy oil)	4	to	329
Sandstone, slaty and shelly, gray	171	to	500
Shale, sandy	78	to	578
Coal	7	to	585
Slate and shells	93	to	678
Sandstone, white, (much salt water) [*Middle Salt*]	12	to	690
Slate and shells	40	to	730
Sandstone, very hard, flaky, (salt water), [*Maxton*]	13	to	743
Shale	18	to	761
Limestone, shaly, not solid, [*Maxville*]	6	to	767
Sandstone, white, very hard	73	to	840
Shale, dark	22	to	862
Red rock	18	to	880
Slate, very black	50	to	930
Sandstone, gray, (salt water and gas)	117	to	1,047
Slate and shells, black	43	to	1,090
Sandstone and shale, black	123	to	1,213
Sandstone, white, soft, (salt water)	2	to	1,215
Slate and shale, black	44	to	1,259
Slate, light, good drilling	216	to	1,475
Sandstone, white, fine, hard, (salt water), [*Berea*]	32	to	1,507
Shale, black, same all through, (cased at 1,520 feet)	951	to	2,458
Sandstone, white, (1 barrel lubricating amber oil dipped), [*Ironton Gas*]	3	to	2,461
Slate and shale, very black, soft	404	to	2,865
Limestone, very hard, perfectly dry	45	to	2,910

The well head is somewhere near the horizon of the Ames limestone or about the middle of the Conemaugh formation. The record shows the Maxville limestone to be quite thin, while other records in this county show the bed to be well developed. Apparently it is somewhat patchy, which condition is well illustrated by the sections made by the drill in Lawrence County. The Berea sand, lying above the thick deposit of Ohio shale, has about normal volume and about its usual characteristics. The Maxton and the Middle Salt sands occupy practically the same positions they hold in the Willowwood field in Lawrence County.

BEREA SAND

The Berea has been the main sand exploited for oil and gas in Gallia County. From the records and information obtained, it appears to hold the persistent continuity it shows in the counties to the west and north. Although this bed has yielded neither oil nor gas in paying quantities in the western part of Gallia County, it has furnished both products for the general market in Addison and Cheshire townships in the eastern part. The interval from the top of the Maxville limestone, or from the base of the Pottsville formation when the former is absent, is approximately 690 feet or about 90 feet greater than it is in the counties to the west. The main points in regard to the search for the natural fuels, oil and gas, in the Berea sand in western Gallia County are next considered.

In the year 1896, Jenkins W. Jones and others drilled a well to the Berea sand on Keton Run, in the northern part of Section 29, Huntington Township. The well head is about 40 feet below the Middle Kittanning coal. No record of the test was obtained, but Mr. Jones supplied the following information:

> The depth of the well was about 1,500 feet. It went to the Berea sand, which, at this place, had a thickness of about 20 feet. We drilled about 60 feet deeper in order to be sure that we had the complete formation. There was no oil in any part of the well, but there was a small flow of gas at a depth of about 400 feet. The Berea sand was rather close-grained and was full of salt water. The outside casing, to control the surface water, extended to a depth of about 100 feet, while the second string of casing, to control the heavy flows of salt water, extended to a depth of about 800 feet. This well was drilled on a flat bench in the coal field to the east of which there was an abrupt dip in the rocks of 50 feet in one-eighth of a mile. There was nothing in this well that offered any encouragement for further drilling in this section of the field.

Just north of Bidwell, on the farm of Aaron Quickle, the drill also reached the Berea sand. No record was obtained, but Mr. Quickle states that the well was drilled to a depth of 1,750 feet, or 50 feet below the base of the Berea sand. Further, he states that the hole was filled with stone to this sand, which was then loosened by explosives, but even after this the well gave only a showing of oil.

A well reported to have reached the Berea sand was drilled on the land of George Glenn, on Barren Creek, in the eastern part of Section

34, Springfield Township. The head of this test is about 100 feet below the Cambridge limestone. No record was obtained, but the test yielded neither oil nor gas in paying quantities. Just east of Rio Grande, and in the northwestern part of Section 26, Raccoon Township, a well was sunk on the land of Harry A. Wood. The test was reported to be between 1,600 and 1,700 feet in depth, which interval easily reached the horizon of the Berea sand. No production was secured. Near Adamsville, on the C. F. Varney property, in the central part of Section 36, Raccoon Township, J. W. Jones and others drilled a test to the Berea formation. A showing of oil was secured in the Berea, but the drill liberated a flood of salt water and the well was a failure. The following log of this well, and the information relating to the county were kindly furnished the Survey by J. W. Jones:

	Depth of stratum. Feet.	Total depth. Feet.
Surface material	26	26
Sandstone	42	68
Slate, coal No. 6a and clay	5	73
Sandstone	26	99
Shale	13	112
Middle Kittanning coal No. 6	7	119
Clay and slate	67	186
Coarse sandstone	7	193
Ferriferous limestone	7	200
Coarse sandstone	25	225
Sandy shale	23	248
Sandstone	42	290
Slate	39	329
Sandy shale	74	403
Coarse sandstone	42	445
Black slate	55	500
Limestone and slate	70	570
Sandstone	16	586
Coal, (No. 1?)	1	587
Sandstone, *Salt* sand	506	1,093
Shale	31	1,124
Sandstone	41	1,165
Cuyahoga shale	145	1,310
Berea shale (black)	20	1,330
Berea grit	15	1,345
Blue shale	8	1,353
Red shale (*Bedford*)	60	1,413
Ohio shale	4	1,417

The salt sand in this record is very unusual. It doubtless includes everything from the top of that formation to near the base of the Big Injun.

On Dirtyface Creek in the southern part of Section 20, Greenfield Township, a well to the Berea sand was drilled on the property of Thomas J. Edwards. The head of the well is only a few feet above the Ferriferous limestone and the work was done by the Planet Oil Company in the year 1913. Fred W. Crawford, of Columbus, Ohio, furnished the Survey the following information in regard to the rocks penetrated by the drill: The Salt sand with a strong flow of water was struck at a depth of 620 feet and continued to a depth of 790 feet, while the Big Injun sand was found at 910 feet and the Berea at 1,193 feet. The Berea sand was 25 feet in thickness and wholly barren of either oil or gas.

In June, 1915, a test of the Berea formation was made on the Ernest Riggs farm, in hope of securing oil or gas in commercial quantities. The well was located south of Raccoon Creek, and about one-fourth mile west of the Gallipolis road near Raccoon Island in Clay Township. The contractor was W. L. Hyde, of Marietta, Ohio, to whom the Survey is indebted for the following record:

	Depth at which reached.
Yellow sand	7
Shell	106
Water	110
Casing, 12½ inch	120
Casing, 10 inch	211
Sand	270
Coal	315
Sand	530
Hole full of water	535
Casing, 8 inch	740
Salt sand	900
Water	905
Hole full of water	910
Big Lime	1,110
White lime	1,140
Keener sand	1,145
Big Injun sand	1,160
Break in sand	1,285
Casing, 6 5-8 inch	1,450
Salt water	1,500
Top of *Berea Grit*	1,764
Bottom of *Berea Grit*	1,777
Bottom of well	1,780

The well made a small showing of oil in the top of the Berea sand. However, after shooting, it gave a strong flow of water, but only a small quantity of oil.

MAXTON AND MIDDLE SALT SAND WELLS

Four shallow wells, in which the horizons reached by the drill are not definitely known, owing to lack of data, have been drilled in the western part of Gallia County. Many years ago a shallow test was drilled on the land of Dr. G. K. Ewing, which is located just south of the village of Ewington, in Huntington Township. The drill is reported to have descended to a depth of about 500 feet and to have stopped in limestone, probably the Maxville. The well yielded a trifling flow of gas for many years. Two shallow tests were drilled north of Bidwell on the Adkins property, now owned by Aaron Quickle. They yielded only small flows of gas which probably came from either the Maxton or Middle Salt sand. No definite information regarding these wells was secured. A shallow test located on the land of C. F. Varney, and just east of the bridge that crosses Raccoon Creek at Adamsville, was drilled many years ago, and is yet producing a small flow of gas. It is reported to be a shallow well, probably extending no farther than the Maxton sand.

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[1] Prepared by Miss Gertrude S. Kellicott.

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